

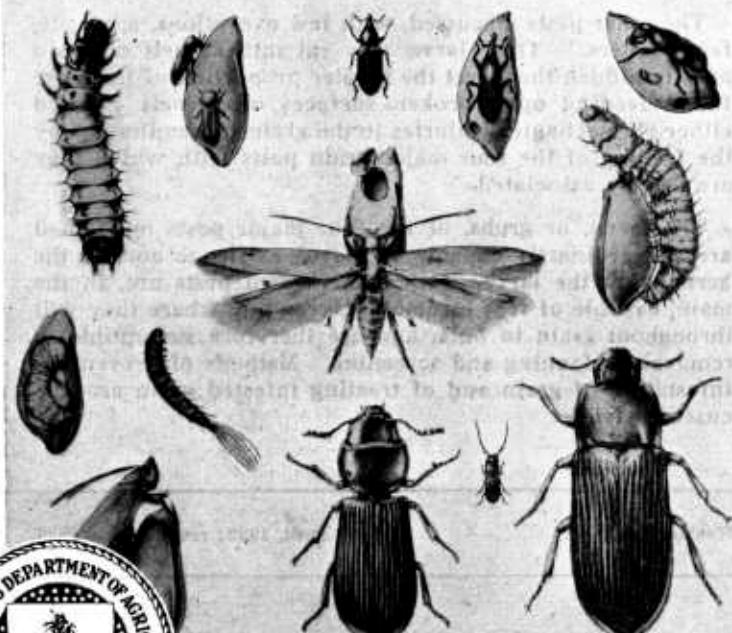
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U. S. DEPARTMENT OF
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STORED-GRAIN
PESTS



MOST of the damage done by insects to grain in storage and shipments is due to four species. These are the granary weevil, the rice or black weevil, the lesser grain borer or Australian weevil, and the Angoumois grain moth. Others of the 46 species or groups of species described in this bulletin can cause great damage to grain if storage conditions are unusually favorable for their increase. Yet if grain in the unbroken kernel remains unaffected by the four insects mentioned, it is not likely, in commercial storage or shipments, to be sufficiently affected by other insects to cause appreciable loss. These four pests live throughout their larval life entirely within the kernel, where they feed unseen, usually unsuspected, and where they can not be reached by the ordinary methods employed by grain men in their grain-cleaning operations known to the trade as moving, fanning, and screening.

The other pests discussed, with few exceptions, are "surface feeders." Their larvae may eat into kernels of grain and lie hidden there, yet the greater proportion of them are found feeding upon broken surfaces of kernels exposed either by mechanical injuries to the grain in handling or by the feeding of the four major grain pests with which they are usually associated.

The larvae, or grubs, of the four major pests mentioned are not ordinarily capable of a free existence outside the kernel, but the larvae of the other grain pests are, in the main, capable of free locomotion, crawling where they will throughout grain in bulk, and are therefore susceptible to removal by fanning and screening. Methods of preventing infestation of grain and of treating infested grain are discussed briefly.

STORED-GRAIN PESTS

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CONTENTS

| Page | Page |
|--|------|
| Popular classification of grain pests..... | |
| Grain weevils..... | |
| Granary weevil..... | 1 |
| Rice or black weevil..... | 2 |
| Broad-nosed grain weevil..... | 3 |
| Coffee-bean weevil..... | 6 |
| Grain borers..... | 7 |
| Lesser grain borer..... | 7 |
| Larger grain borer..... | 9 |
| Grain moths..... | 11 |
| Angoumois grain moth..... | 11 |
| Wolf moth..... | 11 |
| Pink corn worm..... | 13 |
| Rice moth..... | 14 |
| Flour moths..... | 14 |
| Indian meal moth..... | 16 |
| Mediterranean flour moth..... | 16 |
| Meal snout moth..... | 18 |
| Mealworms..... | 20 |
| Yellow meal worm..... | 20 |
| Dark meal worm..... | 22 |
| Grain and flour beetles..... | 26 |
| Cadelle..... | 26 |
| Saw-toothed grain beetle..... | 28 |
| Merchant grain beetle..... | 28 |
| Square-necked grain beetle..... | 28 |
| Foreign grain beetle..... | 29 |
| Mexican grain beetle..... | 29 |
| Siamese grain beetle..... | 30 |
| Flat grain beetle..... | 31 |
| Grain and flour beetles—Continued. | |
| Rust-red grain beetle..... | 32 |
| Confused flour beetle..... | 32 |
| Rust-red flour beetle..... | 33 |
| Long-headed flour beetle..... | 34 |
| Broad-horned flour beetle..... | 34 |
| Slender-horned flour beetle..... | 35 |
| Small-eyed flour beetle..... | 35 |
| Tobacco beetle..... | 36 |
| Drug-store beetle..... | 36 |
| White-marked spider beetle..... | 37 |
| Brown spider beetle..... | 38 |
| Catorama beetle..... | 38 |
| Black carpet beetle..... | 38 |
| Larger cabinet beetle..... | 38 |
| Small cabinet beetle..... | 39 |
| Museum beetle..... | 40 |
| Two-banded fungus beetle..... | 40 |
| Black fungus beetle..... | 40 |
| Lesser meal worm..... | 40 |
| Corn sap beetle..... | 40 |
| Book-lice or psocids..... | 41 |
| Mites..... | 42 |
| Parasites of grain pests..... | 42 |
| How grain becomes infested..... | 43 |
| How to prevent primary infestation..... | 44 |
| The treatment of infested grains..... | 45 |
| Heat..... | 45 |
| Fumigation..... | 45 |

POPULAR CLASSIFICATION OF GRAIN PESTS

SINCE THE ESTABLISHMENT of the Federal standards for grain under the provisions of the grain standards act, Federal grain supervisors and federally licensed grain inspectors are required to identify the various species of "live weevils and other insects injurious to stored grain" which may be present in the grain, and uniform names for grain insects should be used. Such uniform terminology will indicate definitely to all interested persons, including shipper, purchaser, and elevator operator, the exact nature of the insect found. Of the four major pests, the granary weevil, the rice or black weevil, and the lesser grain borer may be well called "grain weevils." The fourth of the major pests, the Angoumois grain moth, so destructive to wheat and corn, may be called "grain moth." Other insects likely to be found in any lot of grain may be called simply "beetles," "moths," and "meal worms," for their pres-

ence usually does not indicate a condition likely to affect the trade, provided that after the grain has reached the elevator it is screened and fanned to remove these insects.

The writers have divided the insects discussed in this bulletin into grain weevils, grain borers, grain moths, flour moths, meal worms, grain and flour beetles, psocids, and mites. In some respects this is not a satisfactory grouping, especially for the insects listed as "grain and flour beetles," but it has the advantage of definitely placing the most serious insects troublesome in bulk grain.

GRAIN WEEVILS

Of the four true weevils that attack grain in the United States only two are of primary importance at present, the granary weevil and the rice or black weevil. The broad-nosed grain weevil and the coffee-

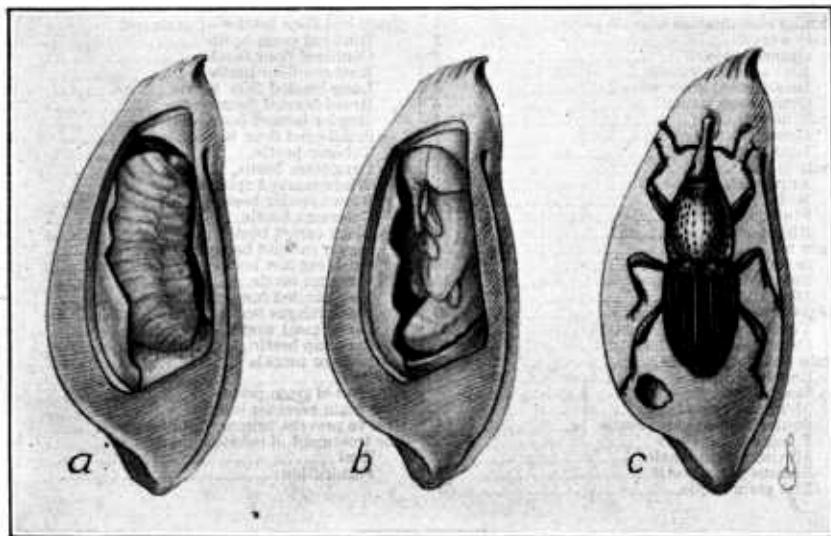


FIGURE 1.—Life stages of the granary weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult. Note hole in kernel made by the adult in order to leave the seed and hole that it is eating into the kernel for the purpose of laying eggs. This weevil closely resembles the rice weevil, but has no papery wings beneath its wing covers and the dotlike punctures on the back behind its head are elongate rather than round.

bean weevil are of minor importance except locally. These four weevils have an elongated beak or snout, as shown in the illustrations, though the beak of the coffee-bean weevil is greatly reduced.

GRANARY WEEVIL

The granary weevil, *Sitophilus granarius* L. (fig. 1), is a small, moderately polished, chestnut-brown or blackish beetle with head prolonged into a long slender snout at the end of which are a pair of stout mandibles or jaws. It is not more than three-sixteenths of an inch long, and often smaller. It has no wings under its wing covers and the thorax is well marked with longitudinal punctures,

two characteristics that distinguish it from the closely related rice weevil, with which it is often found associated. The well-grown footless, whitish grub or larva and the pupa are shown at *a* and *b*, respectively, in Figure 1. The granary weevil is one of the oldest known insect pests, is a universal feeder upon grains, and is cosmopolitan, having been carried by commerce to all parts of the world. It prefers a temperate climate and is more frequently found in the Northern States than in the South.

Both adults and larvae feed voraciously on a great variety of grains. The adult weevils live, on an average, from seven to eight months, the females laying from 50 to 250 eggs each during this period. Before laying her eggs the female bores a small hole in the grain berry with her mandibles. When this has been made she turns about and lays in it an egg which she then covers with a gelatinous fluid that seals the hole. The small, white, fleshy and legless grubs that hatch from the eggs burrow about inside the kernels. When fully grown these transform to the pupal stage and then into the adult weevil form.

In warm weather the granary weevil requires about four weeks to complete its development from the egg to the adult weevil. The developmental period is greatly prolonged by cold weather.

RICE OR BLACK WEEVIL

The rice or black weevil, *Sitophilus oryzae* L., is a small snout-beetle which varies considerably in size but rarely measures more than one-eighth of an inch in length. (Figs. 2 and 3.) It varies in color from reddish brown to nearly black and is usually marked on the back with four light reddish or yellowish spots. It closely resembles the granary weevil in form, but it has well-developed wings beneath its wing covers, differs in color and markings, and has the thorax densely pitted with round, instead of longitudinal punctures. Figure 2 gives a good impression of the appearance of the rice weevil and its earlier stages.

This weevil has been known from early times. It is found in all parts of the world where grain is used and is one of the very worst pests in stored grain. It is particularly abundant in warm countries, where it breeds continuously and rapidly destroys all unprotected grain. Throughout the South it causes tremendous losses to corn (figs. 4, 5, 6, and 7) and is the commonest of the serious pests of commercial grain shipments.

The adult weevil lives, on an average, four or five months, each female laying between 300 and 400 eggs during this period. The early stages are almost identical in habit and appearance with those of the granary weevil and need not be further described. The rice weevil is a strong flier. The adults fly from granaries to the fields of grain and there start the infestation that often proves so disastrous after the grain has been harvested. During summer weather the egg, larva, and pupa stages may be passed in as few as 26 days. This period, of course, is greatly prolonged during cool or cold weather. For a further discussion of this pest see Farmers' Bulletin 1029, United States Department of Agriculture.

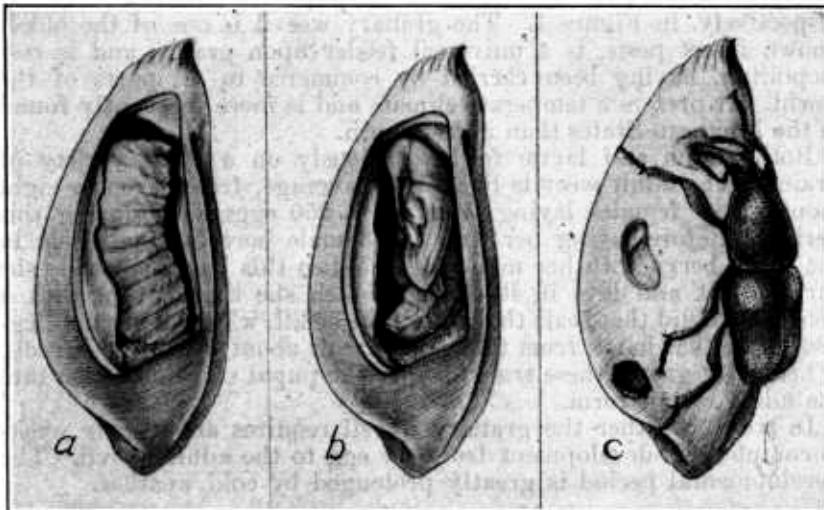


FIGURE 2.—Life stages of the rice or black weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult feeding upon kernel. Note in *c* the hole in lower portion of kernel made by the adult on leaving the seed and at two points higher up shallow holes made by the adult in feeding upon the seed after emergence. The adult weevil is at once distinguished from the granary weevil, shown in Figure 1, by the four light reddish brown or yellow spots on its wing covers, by the possession of wings beneath the wing covers, and by the many rounded punctures on the back behind its head.

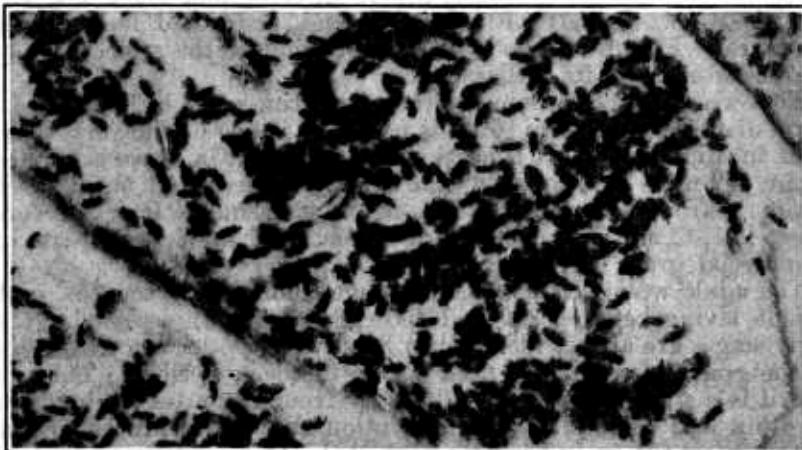


FIGURE 3.—The rice or black weevil: Many adult weevils caught in the mesh of a cloth sack containing pearl barley. Compare their size with that of the barley kernels. Adult weevils when disturbed usually "play possum," but if spread upon a cloth in the sun the live ones will soon show signs of life.



FIGURE 4.—Ear of corn with a poor, loose shuck. It is badly infested with rice or black weevils. As the adult weevils feed, they push from the kernels the chewed-up portions, frass, etc., and this material, resembling white dust, collects in large quantities between the kernels and the shuck, or, if the ears are shucked, it falls like powder onto any object below the ear. (Back)



FIGURE 5.—An ear of corn badly damaged by rice or black weevils. This ear has been hit against a table to jar loose the powdery substance, sometimes called the farinaceous material, and so reveals the great damage done by the weevils. The kernels of the ear have been reduced to powder and shell. (Back)

BROAD-NOSED GRAIN WEEVIL

The broad-nosed grain weevil, *Caulophilus latinasus* Say, is a small dark-brown snout beetle slightly less than one-eighth of an inch long. In form and color it resembles the granary weevil somewhat but differs from it and other grain-infesting weevils by having a short, broad snout. (Fig. 8.)

This weevil is occasionally found in Georgia and South Carolina and is widespread in Florida, where it is a serious pest of stored grains. It is unable to breed in dry, hard, uninjured grain, but attacks soft or damaged grain, or grain that has been attacked by other grain insects. It is a strong flier, and, like the rice weevil, flies to the cornfields and infests the grain before it becomes fully hardened.

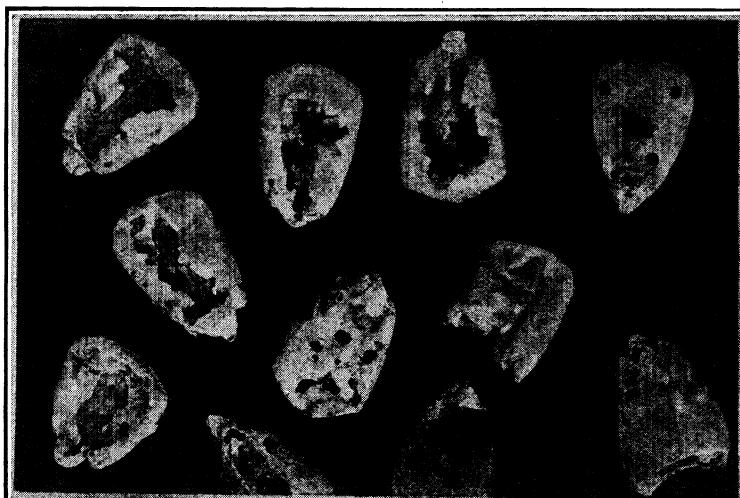


FIGURE 6.—Kernels of corn taken from badly infested ear corn, showing how the rice or black weevils can thoroughly destroy all parts of the kernel. (Back)

The adult weevils normally live for about five months, and during this time the females lay between 200 and 300 eggs. The small white eggs are usually laid in broken portions of the grain. They hatch in a few days, and the small, white, legless grubs feed on the softer portions of the grain until they become fully grown. They then change to a white pupal form which in a few days transforms to the adult beetle and cuts its way out of the grain. The period from egg to adult in summer is about one month.

COFFEE-BEAN WEEVIL

The coffee-bean weevil, *Araecerus fasciculatus* DeG., is a very active, robust beetle from two-sixteenths to three-sixteenths of an inch long, dark brown in color, clothed with a mottled light and dark-brown pubescence. It may be easily recognized from Figure 9.

This weevil is found in many countries and is extremely abundant in the Southern States, where it breeds in dried fruit, coffee

berries, cornstalks, corn, and the seed and seed pods of an almost endless variety of plants. It is a strong flier and is frequently to be seen in the cornfields of the South on the exposed and damaged ears. It lays its eggs in the soft kernels of corn, and breeding continues after the corn has been harvested and placed in storage. It does not cause much damage to corn in storage, as the corn becomes too hard to be attractive. It may, however, be very abundant locally in corn in Florida during the first three months of storage, and has been reported as completely destroying a sack of kafir seeds in Honolulu. Taking the country at large, the coffee-bean weevil is a very minor grain pest. Figure 10, *a* and *b*, shows the rather characteristic holes cut in the kernels of corn and in corn shucks by the larvæ and emerging adults.

GRAIN BORERS

Two species of grain borers are now established in the Southern States. The lesser grain borer bids fair to become a very serious pest of grain throughout the South. The larger grain borer has not yet become a factor in commercial shipments of grain.

LESSER GRAIN BORER

The lesser grain borer, *Rhizopertha dominica* Fab., known to many grain dealers more popularly as the "Australian wheat weevil," because of the large supplies of wheat infested by it that reached this country from Australia during the war, is one of the smallest beetles injurious to grain in this country. It is widespread in the Gulf States, and grain samples infested with this beetle are to be found in many large grain centers. It is readily distinguished from other grain pests by its slender cylindrical form and small size. It is



FIGURE 7.—Slip-shuck corn showing holes eaten through the shuck by the rice or black weevil. These holes make passages through which all kinds of grain pests move back and forth to bring about a more speedy destruction of the kernels. (Back)

polished dark brown or black in color, with a somewhat roughened surface, about one-eighth of an inch long and one thirty-second of an inch wide. Its head is large, prominent, and bent down under the thorax. The larva, pupa, and adult stages are illustrated in

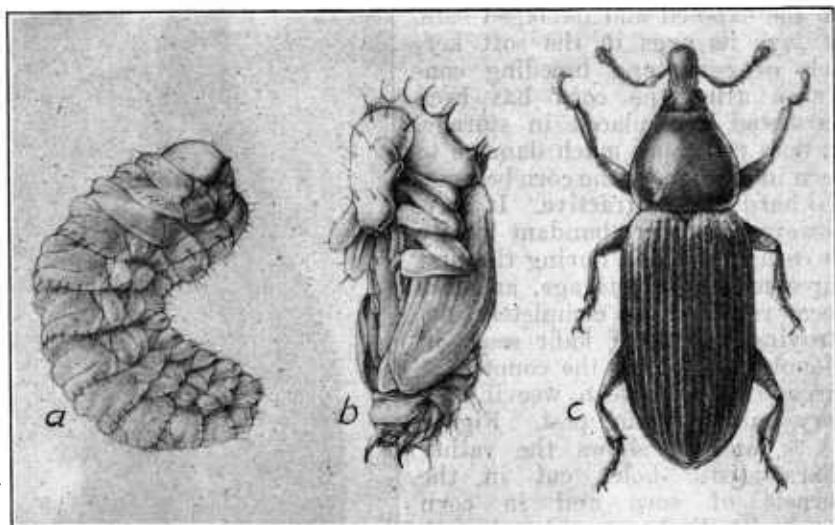


FIGURE 8.—The broad-nosed grain weevil: *a*, Full-grown larva; *b*, pupa; *c*, adult weevil. This weevil is not found in northern-grown grains. It is now present in the southeastern Gulf States. The adult weevil is slightly less than one-eighth of an inch long. It is distinguished from the rice and granary weevils by its much shorter beak

Figure 11. It belongs to a family (Bostrichidae) of beetles that have the head turned down under the thorax and are armed with powerful jaws with which they can cut directly into wood. Originally native to the Tropics the lesser grain borer has spread through commerce to all parts of the world.

Both beetles and larvæ cause serious damage in warm climates, attacking a great variety of grains. The destruction of which they are capable is shown

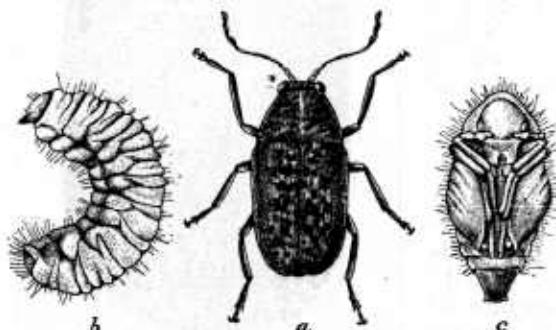


FIGURE 9.—The coffee-bean weevil: *a*, Adult; *b*, well-grown larva; *c*, pupa. The adult is about three-sixteenths of an inch long, of a dark brown color covered with a light and dark brown hairiness. (Chittenden)

by the wheat kernels of Figure 12, which are literally riddled by the boring adults and their young. The females lay from 300 to 500 eggs each, dropping them singly or in clusters in the loose grain. The eggs hatch in a few days and the small whitish grubs crawl actively about the grain, feeding on the flour produced by the boring

of the beetles, or boring directly into grains that have been slightly damaged. They complete their growth within the grain, transform to white pupæ, and in time change to adult beetles which cut their way out of the grain. The period from egg to adult in summer is said to be about a month.



FIGURE 10.—Work of the coffee-bean weevil; *a*, Holes made in corn shucks by the adult weevils eating their way out from the kernels beneath; *b*, two kernels in which larvae of this insect have developed. Note that a single larva devours a large portion of a single kernel, which is not true of the rice weevil

LARGER GRAIN BORER

The larger grain borer, *Dinoderus truncatus* Horn, is a small, dark brown, elongate-cylindrical beetle about one-sixth of an inch long. As may be seen in Figure 13, it is very similar in appearance to the lesser grain borer, but may be distinguished by its larger size and comparatively smooth, polished surface.

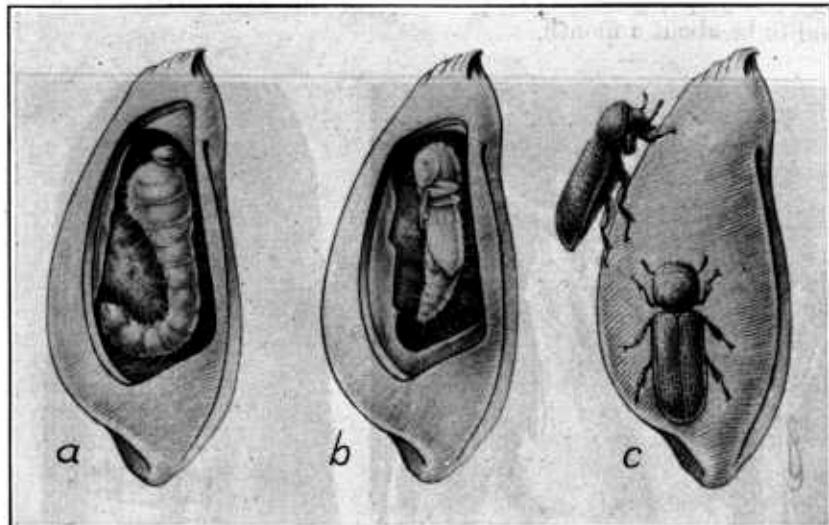


FIGURE 11.—The lesser grain borer in wheat kernels: *a*, The well-grown larva; *b*, the pupa; *c*, two adult weevils. Adult borer is shiny roughened dark brown or black, about one-eighth of an inch long



FIGURE 12.—Kernels of wheat thoroughly riddled and devoured by the boring and feeding of the lesser grain borer and its larva. Such damaged kernels are always surrounded by much powder or flourlike material which the insects have chewed up and pushed out from the kernels

This beetle is a tropical insect not as yet widely distributed in this country. It is occasionally found infesting corn (fig. 14) in the Southern States. Its habits are similar to those of the lesser grain borer. It also has probably acquired its grain-feeding habits rather recently.

GRAIN MOTHS

The grain moths include only those moths capable of destroying sound, unbroken grain kernels. They are not so abundant as the flour moths, which are principally pests in broken, damaged kernels or milled products.

ANGOUMOIS GRAIN MOTH

The Angoumois grain moth, *Sitotroga cerealella* Oliv., is a small buff or yellowish-brown moth with a wing expanse of about one-half inch. This is the moth most commonly found in infested grain in this country and is not likely to be confused with any other. It attacks all cereal grains, is found in all parts of the world, and is particularly injurious in the South, where it attacks grain both in the field and in storage.

Each female moth may lay as many as 400 eggs, which are white when first laid but soon change to a reddish color. The eggs are laid on or near the grain. Upon hatching, the minute white larva or caterpillar bores into a kernel of grain and begins feeding on the contents. When full grown it eats out a channel to the outside of the seed but leaves a thin layer of the seed coat intact. It then changes to a reddish-brown pupa, and later the adult or moth emerges, pushing aside the thin section of seed coat that covers the exit from the channel. The development from egg to adult may be completed in five weeks. Figures 15 and 16 show the successive stages in the development of this insect in a kernel of wheat and of corn from the time the egg is laid until the adult appears. In Figure 17 is shown an ear of corn with the external evidence of heavy attack, and in Figure 18 are shown wheat kernels with the emergence holes of the moth. For a further discussion of this pest see Farmers' Bulletin 1156, The Angoumois Grain Moth.



FIGURE 14.—Kernel of corn showing work of a adult of larger grain borer. The adult borers tunnel in all directions and reduce kernels to powder and shells. Enlarged. (Chittenden)

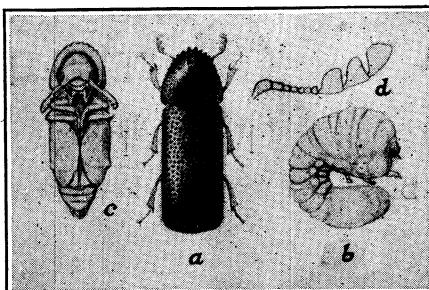


FIGURE 13.—The larger grain borer: a, Adult insect; b, larva; c, pupa; d, antenna of adult. Adult borer is shiny polished dark brown, about one-sixth of an inch long. a, b, c, About six times natural size; d, highly magnified. (Chittenden)

WOLF MOTH

The wolf moth, *Tinea granella* L., is a small moth about the size of the Angoumois grain moth, creamy white and thickly mottled with brown. The mottled appearance distinguishes it from the Angoumois grain moth. It infests all kinds of grain, both in the

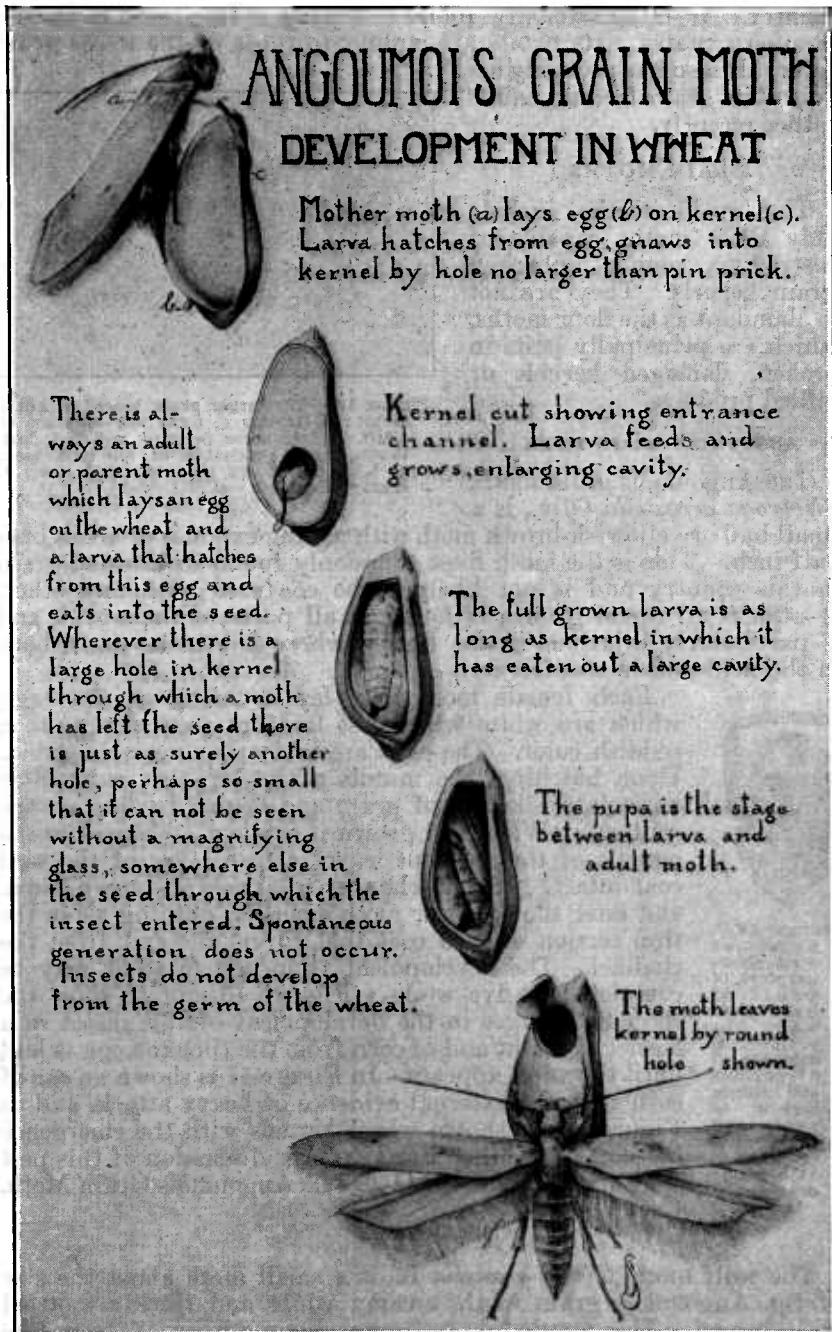


FIGURE 15.—Life cycle of Angoumois grain moth on wheat. (Back)

field and in storage. The larva feeds on the grain and webs the kernels together.

The wolf moth is distributed throughout the Northern States but is not very abundant and can not be compared with the Angoumois grain moth for destructiveness.

PINK CORN WORM

The pink corn worm, *Pyroderces rileyi* Wals., is the larva or caterpillar of a small moth. (Fig. 19.) It is about five-sixteenths of an inch long when full grown; pink in color, with head and thoracic shield pale brown. Figure 20 gives a good idea of its appearance. The moth which develops from this worm or larva is smaller than the Angoumois grain moth, with a wing expanse of slightly less than half an inch. The forewings are banded and mottled with yellow,

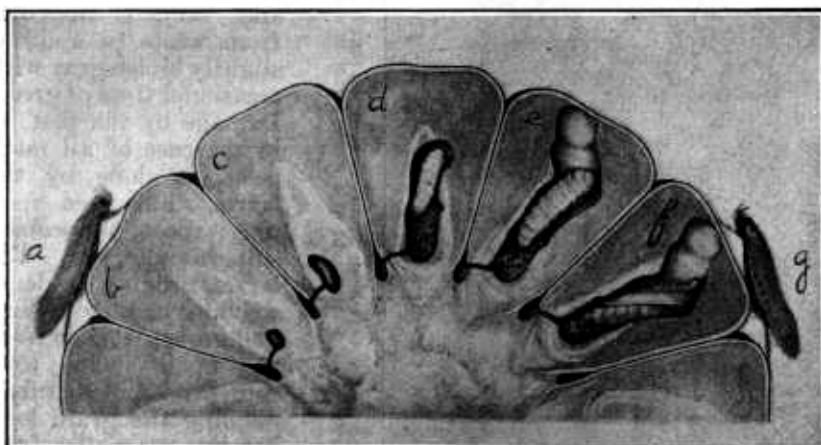


FIGURE 16.—Cross section of ear of corn showing development of Angoumois grain moth in corn. The newly hatched larva crawls down to the germ end of the corn and begins feeding upon the soft germ. As it grows older and stronger it eats out into the firmer portion of the kernel and finally, in most instances, eats to the outer end. (Back)

reddish brown, and black, as shown by Figure 19. The pale grayish hindwings are very slender and are edged with long fringes. The pupa is shown in Figure 21.

This insect is common in the South, where it causes considerable injury to corn, both in the field and in storage. Infestation begins in the field and is continued after the corn is placed in storage. The very characteristic injury is shown in Figures 22 and 23. The large amount of frass that is loosely webbed together and fills the interstices between the kernels or is crowded into the cavities of kernels that have been eaten out is a reliable indication of the presence of this pest. The pearly white eggs are laid singly or occasionally in twos or threes. The pinkish larvæ feed on the seed, husk, and cob with equal relish. Though capable of serious injury to corn, in particular as it comes to maturity in the field, and while in the cribs on southern farms, the pink corn worm is seldom a serious pest of commercial shipments.

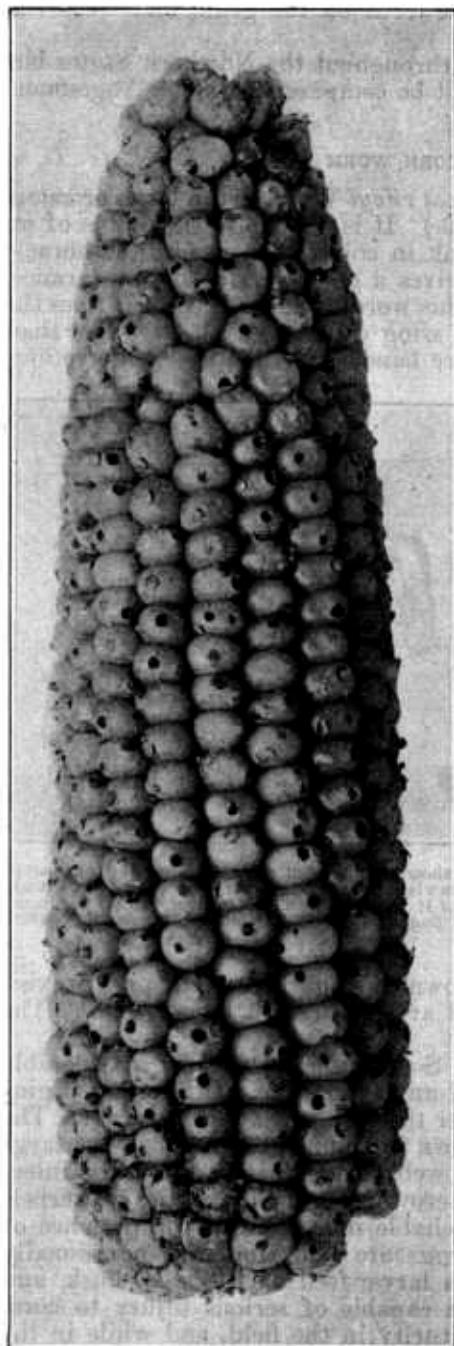


FIGURE 17.—Ear of pop corn showing heavy infestation by the Angoumois grain moth. Note that certain of the kernels have three emergence holes, and that many have served as food for two larvae. The development of a single insect in a kernel causes a loss of from 13 to 24 percent in weight.

RICE MOTHS

The rice moth, *Coryza cephalonica* Staint., has a wing expanse of about half an inch and is of a pale grayish-brown or tawny color. Its characteristic appearance is shown in Figure 24. The larva (fig. 25) resembles somewhat that of the Indian meal moth, being when full grown about half an inch long and varying in color from white to a dirty, slightly bluish gray with occasional tints of green. Damage by the pest, as in the case of all moth pests, is done by the larvae, which feed upon rice, cocoa, chocolate, ship biscuits, etc. The larvae produce a dense webbing as they become well grown. When feeding upon grains they spin dense silken tubes, webbing the grain kernels into the walls of the tubes. The pupa is shown in Figure 26. The rice moth is seldom found in this country and has not become very widely disseminated.

FLOUR MOTHS

Among the flour moths are some of the commonest and most serious pests of grain products. They are designated as flour moths not because they feed entirely upon flour or milled products, but because they seldom attack sound grain kernels. They prefer broken

grains, grains injured by major grain pests, and more especially cereal milled products such as flour, breakfast foods, meals, etc. All three

of the flour moths are commonly found in grain warehouses, but the Indian meal moth and the meal snout moth are probably the most

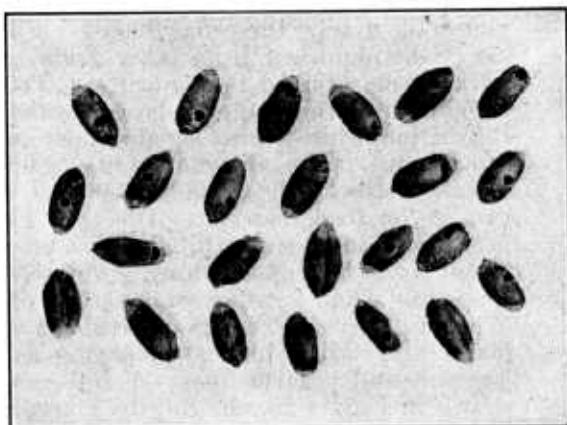


FIGURE 18.—Kernels of wheat showing the small round emergence holes that prove that the Angoumois grain moth has developed in the seed, thus reducing the weight somewhat over 50 per cent. (Back)

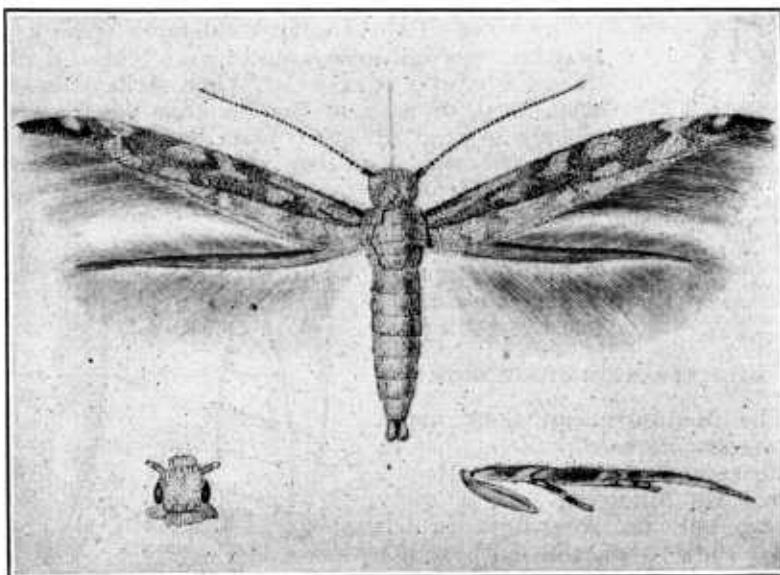


FIGURE 19.—The pink corn worm: Moth, much enlarged; head and leg more enlarged. The moth has a wing spread of a little less than half an inch. (Chittenden)

frequently reported. These two moths may, under specially favorable conditions, become established in whole grain and other seeds and cause injury especially by eating out the germ.

INDIAN MEAL MOTH

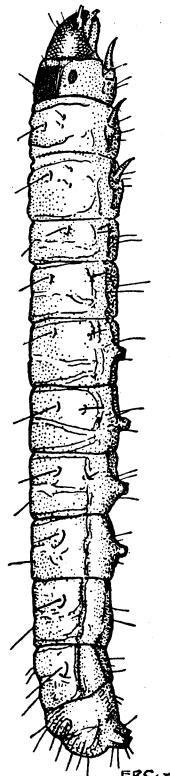


FIGURE 20.—The pink corn worm: Full-grown larva, side view, greatly enlarged. When full grown the larva is pink and about five-sixteenths of an inch long. (Chittenden.)

The Indian meal moth, *Plodia interpunctella* Hbn., is a rather handsome moth with a wing expanse of nearly three-fourths of an inch. It is easily distinguished from other grain pests by the peculiar marking of its forewings. These are reddish brown with a coppery luster on the outer two-thirds, but whitish gray on the inner or body end. Moths and larvae are shown in Figure 27. The female moths lay from 300 to 400 eggs, singly or in groups, on food material. The eggs hatch within a few days into small whitish larvae or caterpillars. These larvae feed upon grains, grain products, dried fruits, nuts, and a rather wide variety of foodstuffs. When full grown, the larvae are about half an inch long, dirty white in color, varying sometimes to greenish and pinkish hues. A full-grown larva is shown in Figure 28, clinging to a kernel of wheat. This larva spins a silken cocoon and transforms to a light-brown pupa, from which the parent moth later emerges. The Indian meal moth may pass through its egg, larva, and pupa stages in about four weeks during warm weather.

The larva of the Indian meal moth spins a web as it becomes full grown, and leaves behind a silken thread wherever it crawls. When sacks of cracked corn, meal, or corn in the ear that has been previously injured by other pests become heavily infested, this webbing often is sufficiently abundant to attract attention.

The loosely clinging web shown on the ear of corn in Figure 29 is characteristic of this pest.

MEDITERRANEAN FLOUR MOTH

The Mediterranean flour moth, *Ephestia kuehniella* Zell., has a wing spread of slightly less than 1 inch. Its hindwings are a dirty white, but its forewings, which alone show when the moth is not flying, are a pale leaden gray with transverse wavy black markings. (Fig. 30.)

The Mediterranean flour moth is a native of Europe. Its first discovery in the United States was in

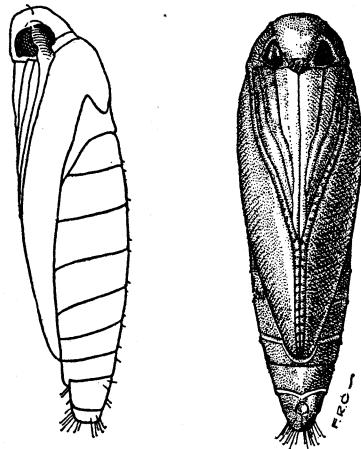


FIGURE 21.—The pink corn worm: Pupa, ventral view at right, lateral view at left. Enlarged. (Chittenden)

California in 1892. Since then it has spread to practically all the States and is recognized as the most serious pest of flour mills, owing to the silken threads which the larvæ spin wherever they crawl. These webs mat the flour or meal together and eventually clog machinery so that mills have to shut down for a thorough cleaning and treatment. Although preferring flour and meal, the Mediterranean flour moth attacks grain, bran, and cereal products and is commonly found in storehouses and granaries.

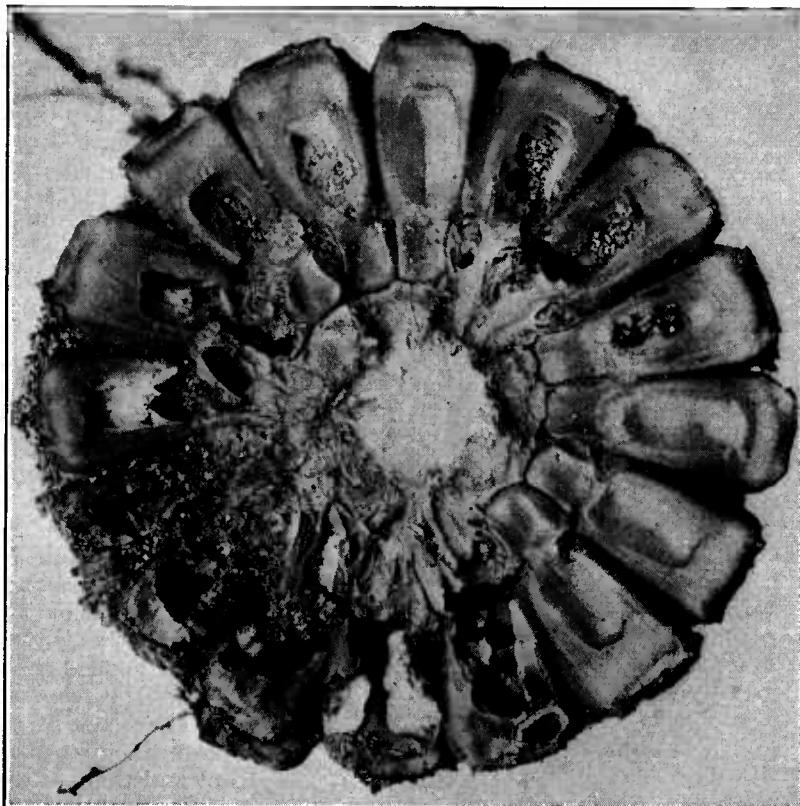


FIGURE 22.—Ear of corn cut to show characteristic feeding and destruction by pink corn-worm larvæ. Note that the larvæ eat from one kernel to another, often severing the kernels from the cob. The larvæ sometimes eat into the cob, and there transform to the pupa stage. The pupæ are about one-third as long as the kernels shown

The female moth lays small white eggs in accumulations of flour, meal, or waste grain. From the eggs the small larvæ hatch in a few days. When full grown, these are about half an inch long and are of a whitish or pinkish color with a few small black spots on the body. The full-grown larva spins a silken cocoon in which the insect transforms to a reddish-brown pupa. Later the parent moth emerges from the pupa. During warm weather, the Mediterranean flour moth requires about nine weeks to pass through its egg, larva, and pupa stages.

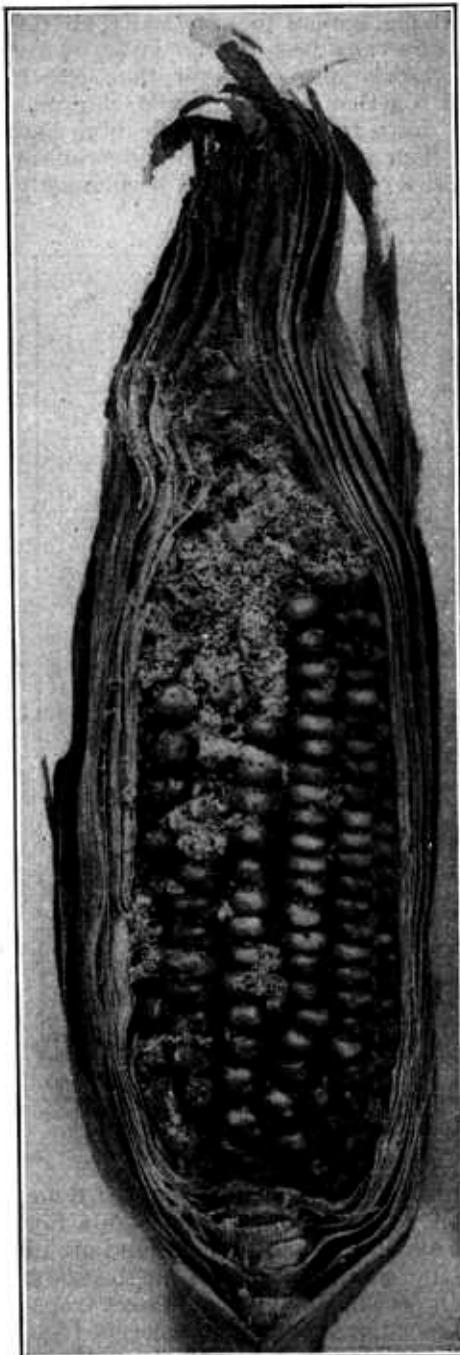


FIGURE 23.—Ear of corn with portion of shuck removed to show surface feeding by larvae of the pink corn worm. Often many kernels drop from the ear when the shucks are removed because of the feeding of the pink corn worm larvae.

MEAL SNOUT MOTH

The meal snout moth *Pyralis farinalis* L., is brownish in color, somewhat larger than the Indian meal moth, though varying in size, usually having a wing spread of about 1 inch. Its forewings are marked in a characteristic pattern indicated in Figures 31 and 32; they are light brown with dark-brown patches at base and tip and each with two wavy transverse white lines. The meal snout moth is widely distributed and a general feeder in the larva stage upon cereals of all kinds, both ground and in the berry. It sometimes attracts much attention because of its capacity to web up and bind together seeds of various kinds. The larvæ are whitish and attain a length when full grown of about 1 inch. The two larger larvæ of Figure 31 indicate the normal shape and show the contrast between the black of the head and the first body segment and the white of the remainder of the body. Often the body of the larva is tinged with orange toward each end. The larvæ spin peculiar tubes of silk and particles of the food material. They rest in these tubes, which are very tough, and feed from the openings at the ends. When full grown the larvæ

leave the tubes, spin silken cocoons, often covered with food particles, and transform to the pupæ from which later emerge the adult moths. The meal snout moth may require only eight weeks to pass through the egg, larva, and pupa stages.

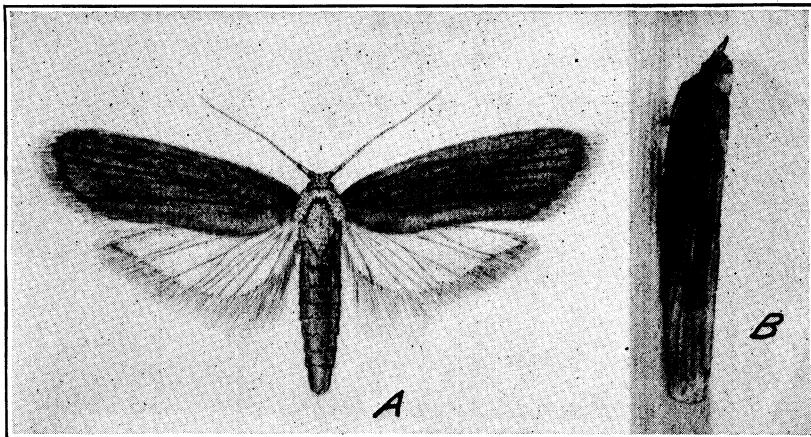


FIGURE 24.—The rice moth: *a*, Mature moth, dorsal view, with wings spread; *b*, side view of same moth with wings folded about body. The moth is of a grayish brown or tawny color, with a wing spread of about half an inch. Much enlarged. (Chittenden)

The meal snout moth is primarily a pest of seeds that are held for some time in cool and damp localities. Outbreaks that have come to the attention of the writers have always been centered in grain that

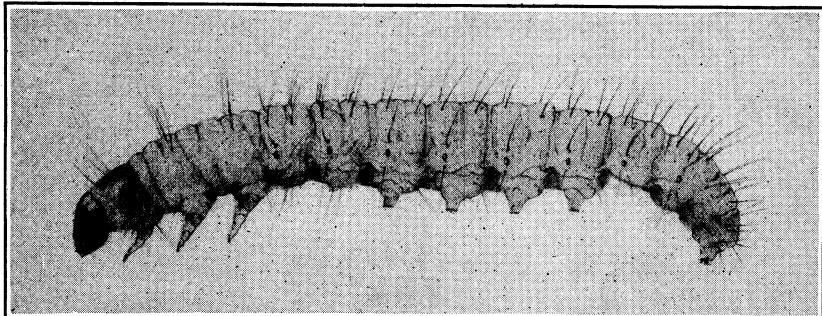


FIGURE 25.—Full-grown larva of the rice moth. The full-grown larva is about one-half inch long, and is of a whitish or bluish gray color. Much enlarged. (Chittenden)

was harvested during rainy weather or so stored that the moisture content was unusually high. Attempts to rear the moth in dry, warm laboratories have failed. The larvæ cut through burlap sacking and can damage sacks greatly when heavy infestations develop in sacked material. Figure 33 shows the characteristic webbing together of infested seeds—in this instance navy beans—and Figure

32 shows the tendency for larvæ to spin their whitish silken cocoons on the outside of grain sacks where the sacks touch each other.

MEAL WORMS

There are two species of meal worms in the United States. The adults are the largest of the beetles found in grain and their larvæ are conspicuous, for they attain a length of about 1 inch and are as large around as an earthworm.

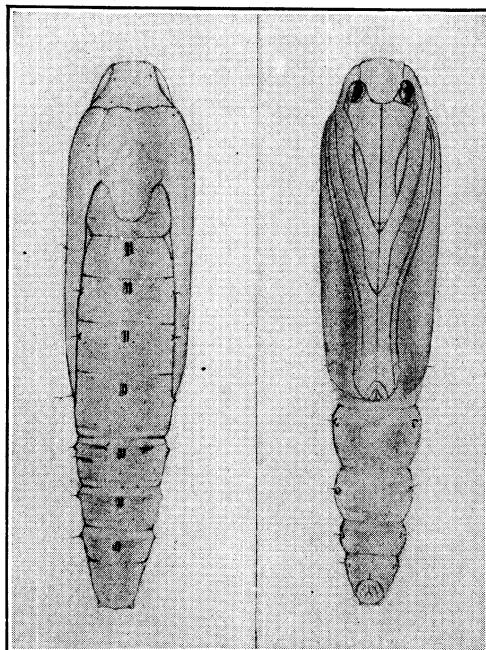


FIGURE 26.—Pupa of the rice moth: At left, dorsal view; at right, ventral view. The pupa is found in a dense tough cocoon into the walls of which have been spun particles of the food. The cocoons of the Indian meal moth, on the other hand, are very loosely constructed. Much enlarged. (Chittenden)

YELLOW MEAL WORM

The adult of the yellow meal worm is a polished dark-brown or black beetle, somewhat more than half an inch long, with its thorax finely punctured and with its wing covers longitudinally striated or grooved. (Fig. 34, right.) The females lay bean-shaped white eggs covered with a sticky secretion that causes the flour, meal, or grain waste in which they are placed to adhere to them. The eggs hatch in about two weeks into slender white larvæ, which soon turn yellow and assume the form shown in Figure 34. When full grown, the larvæ are about an inch long and yellowish, shading to yellowish brown toward each end and at the articulation of each segment. The pupa into which the larva transforms before becoming an adult beetle is shown in Figure 34.

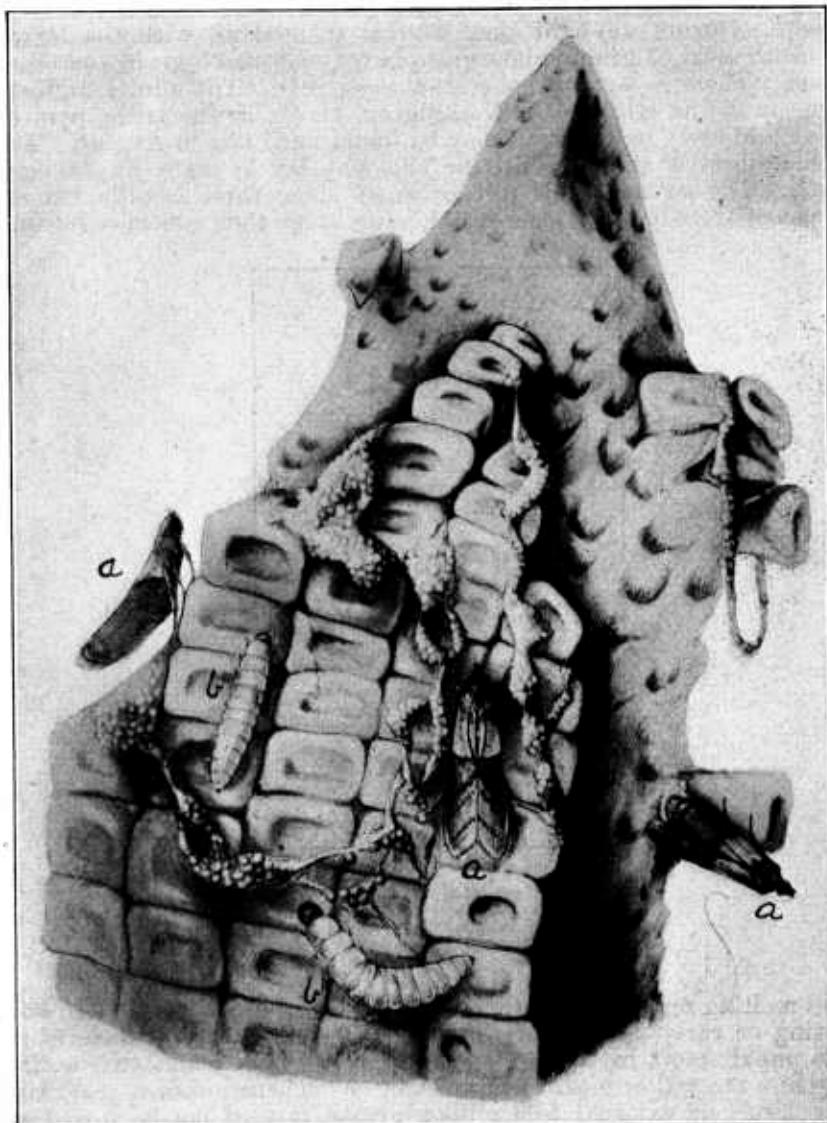


FIGURE 27.—The Indian meal moth: Tip of ear of corn showing, *a*, three moths with their characteristic light and dark markings, and *b*, two well-grown larvae. The adult moth is distinguished from all other grain-infesting moths by having the outer two-thirds of its wings brownish and the inner third whitish gray. It has a wing spread of about three-fourths of an inch

The yellow meal worm, *Tenebrio molitor* L., is widespread over the world and is frequently found in stored grains. It belongs to a family of beetles (Tenebrionidae) known as the darkling beetles because of their preference for dark places. The adults fly only at night. During daylight they conceal themselves, with the larvæ, beneath sacks of grain, under grain boxes, or beneath grain and other food. There is but one generation each year. The adults begin to appear in the latitude of Washington, D. C., in the latter part of May and early in June and may be found until late in August. The female beetles are quite prolific and may lay as many as 500 eggs each. The larvæ become full grown in about three months, but instead of transforming then to the adult stage they continue feeding

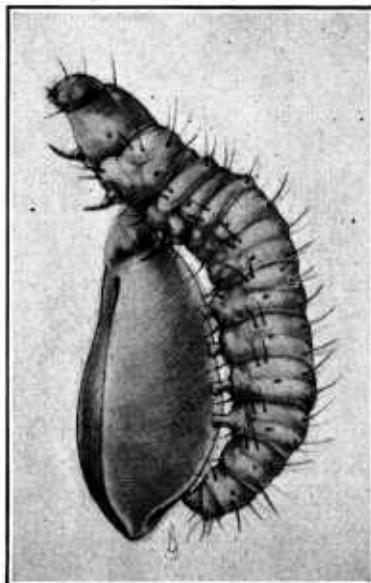


FIGURE 28.—Well-grown larva of the Indian meal moth, crawling on kernel of wheat. These worms are white or greenish in color and frequently eat out the germ end of wheat. They attain a length of about half an inch.

and molting until cold weather and then hibernate as larvæ. In late spring or early summer of the following season they transform to the pupal stage, in which stage the insect passes about two weeks. Because the yellow meal worm has but one generation each year, and is entirely an external feeder upon grains, it need not be feared as a serious pest. Screening and fanning will remove it easily from grain shipments. The well-grown larvæ, however, can do serious injury to whole grains under certain conditions when grain is held for long periods without being moved.

DARK MEAL WORM

The dark meal worm, *Tenebrio obscurus* Fab., as may be seen by the larva, pupa, and adult shown in Figure 35, is very similar in

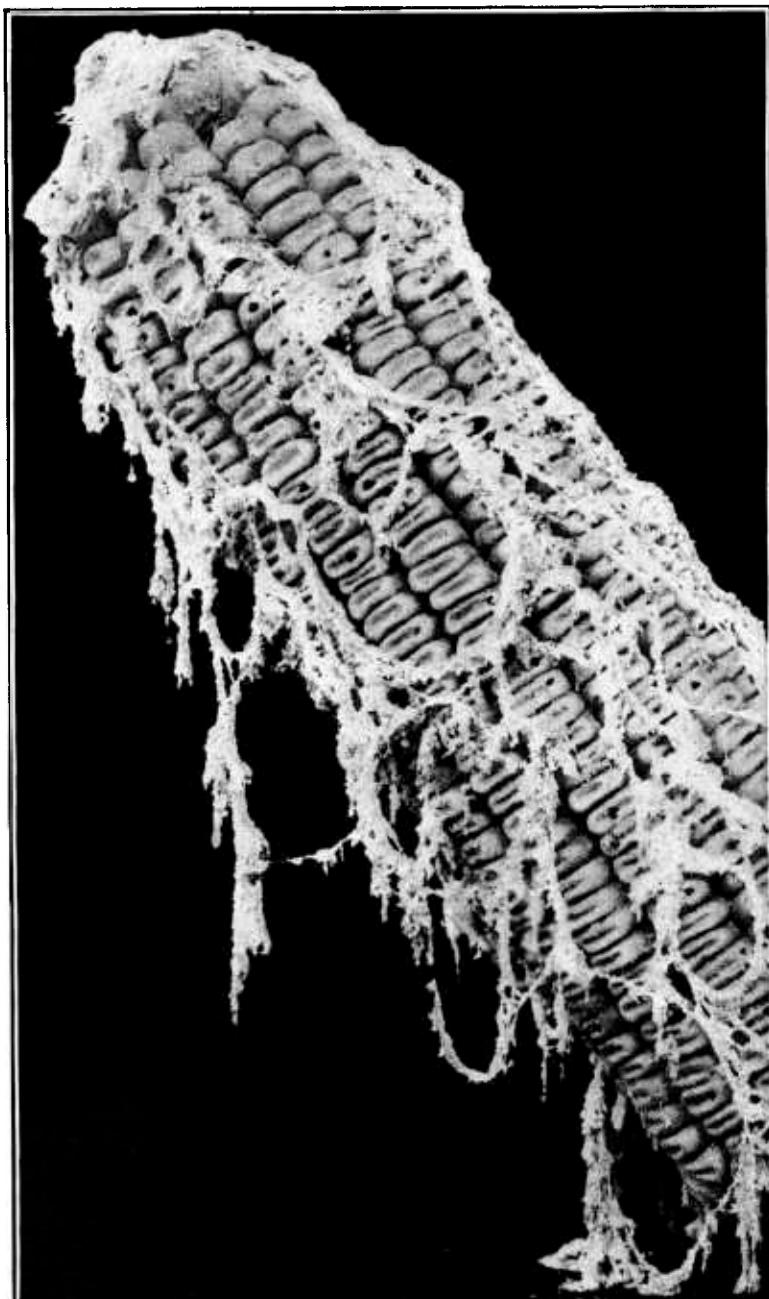


FIGURE 29.—Ear of corn showing the loose webbing characteristic of the Indian meal moth larvae. This moth rarely attacks sound grain, but, as is here shown, frequently attacks grains already injured by other grain pests. Such webbing as is here shown develops only when corn or other grains are left unmoved for some time.

form, size, and color to the yellow meal worm, to which it is closely related. The adult beetle differs, however, in being dull pitchy black, in contrast to the shiny or polished dark brown or black of

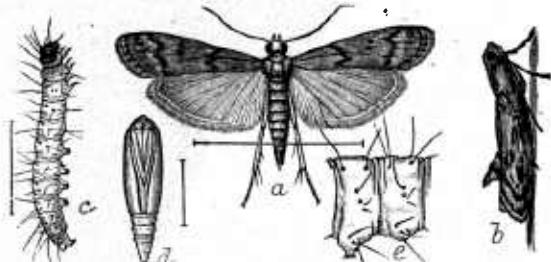


FIGURE 30.—The Mediterranean flour moth: *a*, Moth; *b*, same from side, resting; *c*, larva; *d*, pupa (enlarged); *e*, abdominal joint of larva (more enlarged). The adult moth, with a wing expanse of a trifle less than 1 inch, is leaden gray in color, marked with transverse wavy black markings. The full-grown larva is whitish or pinkish in color, with small black spots, and is about one-half an inch long. (Chittenden)

the yellow meal worm. Its larva so closely resembles the larva of the yellow meal worm that it can be distinguished most easily by its much darker color.

The two species of meal worms are often found associated since they have similar feeding habits. The overwintering larvæ of the

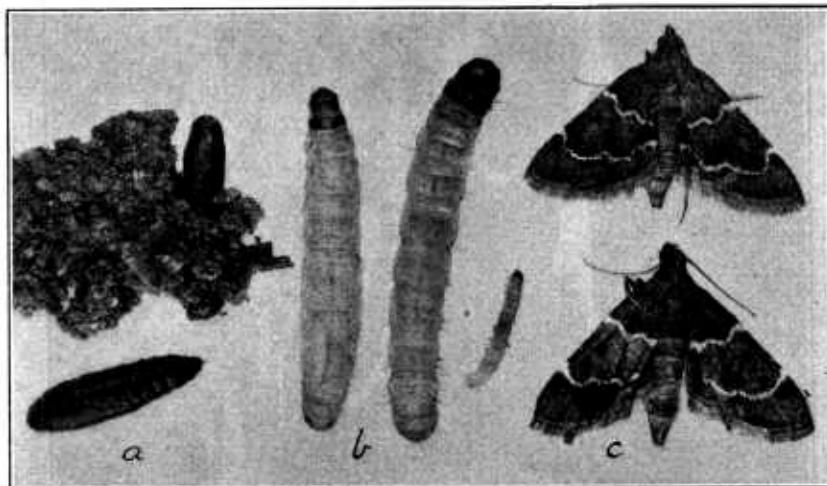


FIGURE 31.—The meal snout moth: *a*, Pupa and, above, webbed mass of grain showing portion of pupa protruding; *b*, two well-known larvæ with a smaller larva at right; *c*, two adult moths. Magnified about one and one-half times. The markings on the forewings easily distinguish this insect from other grain pests

dark meal worm begin to pupate earlier in the season than the yellow meal worms, and the adult beetles emerge during April and May in the vicinity of Washington.



FIGURE 32.—Inside of a grain sack that was filled with infested vetch seed. Note vetch seeds sticking to side of bag as a result of the webs of the larvae of the meal snout moth, the numerous whitish cocoons with dark pupæ within, and, in the center, one adult moth. Natural size

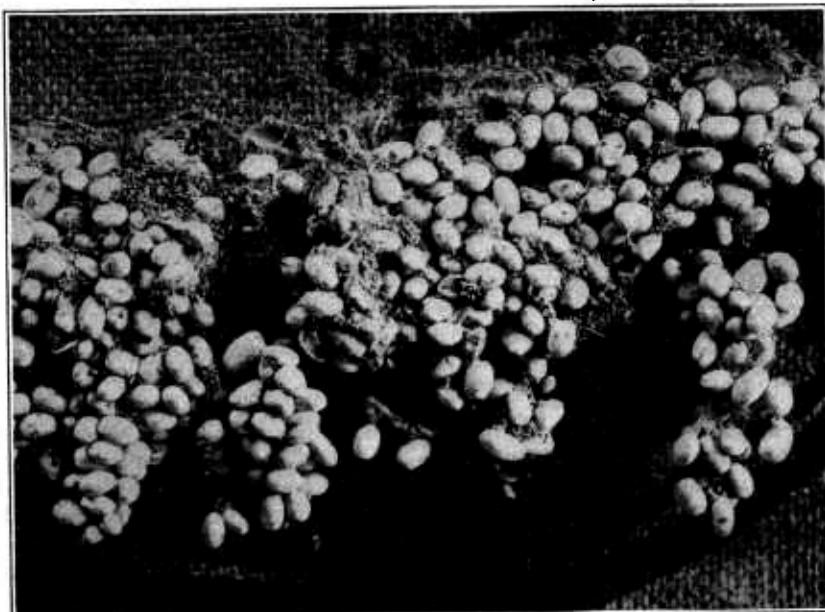


FIGURE 33.—Navy beans webbed together by larvae of the meal snout moth, and adhering to sack. The larvae often cut sacks so seeds fall out and lodge where sacks touch each other. In these places the seeds are usually more heavily infested

GRAIN AND FLOUR BEETLES

CADELLE

The cadelle, *Tenebroides mauritanicus* L., is an elongate, oblong, flattened, black or blackish beetle about one-third of an inch long. It resembles the meal worms in appearance, but is much smaller and the thorax and abdomen are loosely joined. (Fig. 36.)

The larva of the cadelle is one of the largest of the grain-infesting insects and is easily recognized. It is about three-quarters of an inch long, fleshy, with the abdomen terminating in two dark horny points.

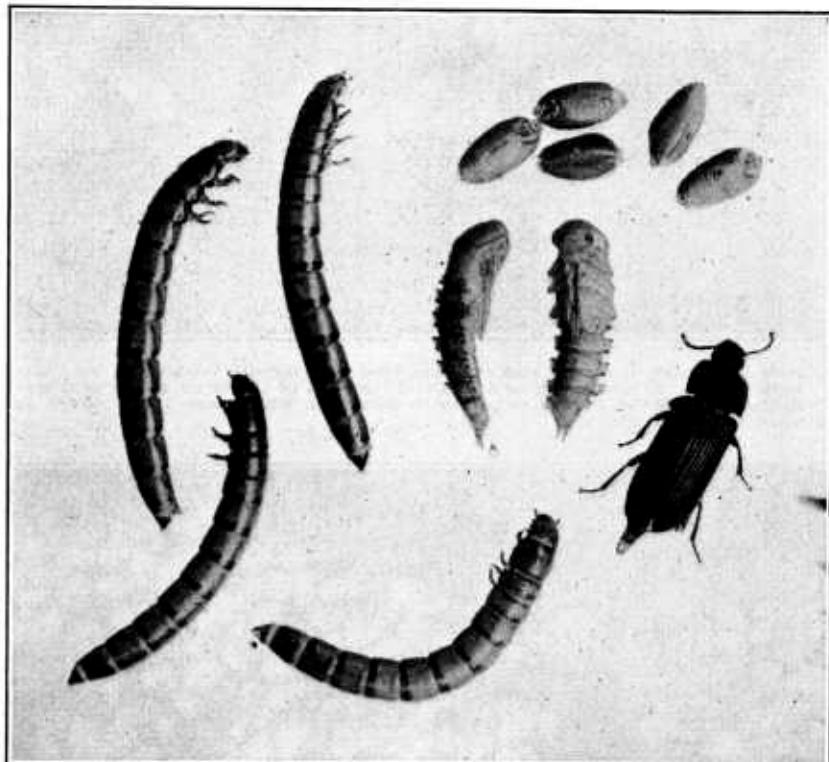


FIGURE 34.—The yellow meal worm. Four well-grown larvae, two pupæ, and the black adult beetle, with five kernels of wheat to indicate relative size. The larvae when full grown are about 1 inch long and yellowish. The adult beetles are shiny black and slightly more than half an inch long.

The larva is a dirty or chalk white, with head, thoracic shield, and the two horny points at end of body black, as shown in Figure 37.

This insect is widespread over the world and is frequently found in mills, granaries, and storehouses, where it infests flour, meal, grain, etc. Both larva and adult feed on grain and have the destructive habit of going from kernel to kernel and devouring the embryo. The cadelle often becomes well established in ear corn (fig. 38) that has first been injured by the Angoumois grain moth or by the weevils. The long slits in corn kernels shown in Figure 38 are char-

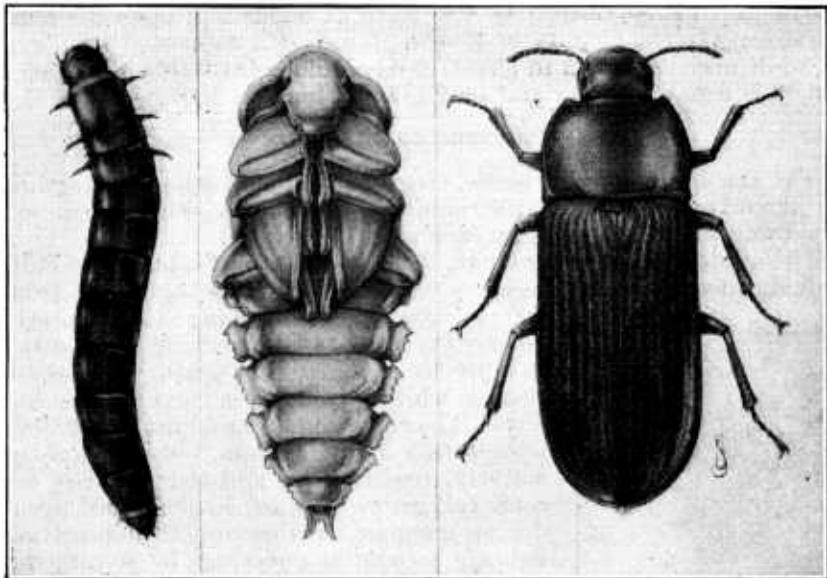


FIGURE 35.—The dark meal worm: *a*, Full-grown larva; *b*, pupa; *c*, adult beetle. Distinguished from the yellow meal worm by the dark brown color of the larva and the dull, not shiny appearance of the adult beetle. For true relative size of the larva, pupa, and adult compare with Figure 34.

acteristic of cadelle infestation. The cadelle is one of the longest lived of the insects that attack stored grain; many of the adults live for more than a year, and some of them for nearly two years. The female beetles oviposit during the greater part of their lives and under favorable conditions will lay about 1,000 eggs each.

The white eggs are laid in clusters in the food material and hatch in from 7 to 10 days in warm weather. The larvæ complete their growth in from 2 to 14 months, then seek some secluded place in which to transform to the pupal stage (fig. 39), frequently boring into the timbers of the bin or other receptacle that holds the infested material. Both larvæ and adults can live for considerable periods without food, frequently remaining hidden in the wood-work of the bins for a long time after the grain has been removed. When new grain is put into such a bin it becomes infested in a surprisingly short time.



FIGURE 36.—The cadelle: Adult beetle. The cadelle is a flattened, black beetle about one-third of an inch long.

The pupal stage lasts from 8 to 25 days, depending upon the temperature. In the vicinity of Washington, D. C., the period from egg to adult may be passed in about 70 days under favorable conditions, but it is usually longer and may take as long as 400 days.

SAW-TOOTED GRAIN BEETLE

The saw-toothed grain beetle, *Oryzaephilus surinamensis* L., gains its name from the peculiar structure of the thorax, which bears six saw-tooth-like projections on each side. (Fig. 40.)

The adults live, on an average, from 6 to 10 months, but some individuals may live as long as three years. The female beetles lay from

100 to 200 eggs, dropping them loosely among the foodstuff or tucking them away in a crevice in a kernel of grain. The small, slender, white eggs hatch in from three to five days. The emerging larvæ do not spend their lives within a single grain, but crawl about actively, feeding here and there. They become full grown (fig. 40) in about two weeks during summer weather and then construct delicate cocoonlike coverings by joining together small grains or fragments of food-stuffs with a sticky secretion. Within this pupal cell the larva changes to the pupal stage, which last about a week. Development from egg to adult may take place in from three to four weeks in summer.

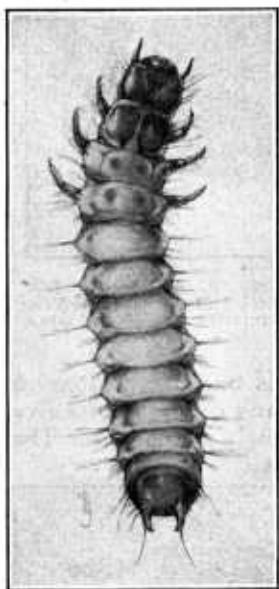


FIGURE 37.—The caddie; Larva. Commonly found crawling among grain kernels. It may appear glistening white or dull and powdered according to the material in which it is crawling. When full grown it is about three-fourths of an inch long.

the two species may many times have resulted in the crediting of infestations of the merchant grain beetle to the saw-toothed grain beetle.

SQUARE-NECKED GRAIN BEETLE

The square-necked grain beetle, *Silvanus gemellatus* Duv., is closely related to the saw-toothed grain beetle, which it greatly resembles in form, size, and color. It is a flattened, oblong, polished, reddish-brown beetle about one-tenth of an inch long. It differs from the saw-toothed grain beetle by having the thorax almost square in shape and lacking the saw-toothlike projections. (Fig. 43.)

MERCHANT GRAIN BEETLE

The merchant grain beetle, *Oryzaephilus mercator* Fauv., closely resembles the preceding species and has similar food habits. It differs in appearance from the saw-toothed grain beetle (fig. 41) chiefly by the much narrower, more sharply projecting temples (fig. 42, a) and in having the head and trochanters (second joint from the base in the leg) of the male unarmed.

It is apparently not so widely distributed in this country as the saw-toothed grain beetle, although the close resemblance between

This beetle is chiefly abundant in the South, where it is found in great numbers outdoors infesting the seed pods of a great variety of plants. It is one of the most common beetles in stored corn in the South and in the cornfields is always to be found on damaged or exposed ears. The immature stages closely resemble those of the preceding species both in form and in habit. The larvae have the bad habit of devouring the germ of the seed in which they breed. They can develop from egg to adult in about three weeks.

FOREIGN GRAIN BEETLE

The foreign grain beetle, *Cathartus advena* Waltl., is a small reddish-brown beetle somewhat similar in appearance to the preceding species, to which it is closely related. It differs from it by being smaller and more robust. (Fig. 44.) Although of world-wide distribution, it is of little consequence as an enemy of stored grains. It is attracted to damp and moldy grains and feeds on the molds developing in such grains. It is rarely found in clean grain.

MEXICAN GRAIN BEETLE

The Mexican grain beetle, *Pharaxonotha kirschi*, Reitt., is a highly polished, deep-brown beetle about three-sixteenths of an inch long. While resembling somewhat the confused flour beetle in general appearance, it can be readily distinguished by its more polished surface and by its longer antennæ. (Fig. 45.)

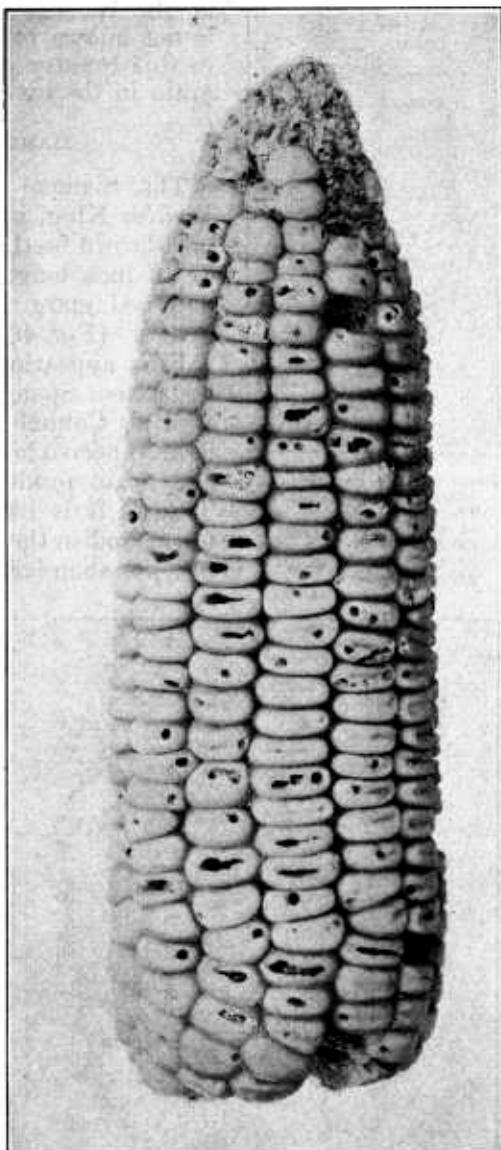


FIGURE 38.—Ear of corn infested by the Angoumois grain moth (round holes in kernels) and the cadelle. The elongated slits in the kernels are characteristic of cadelle feeding and emergence. Only ear corn stored for several years will develop this evidence of cadelle attack.



FIGURE 39.—The cadelle: Pupa, much enlarged. The pupa is seldom seen, as this stage of the cadelle's life cycle is spent in a cell made in an inaccessible place.

This insect is common in Mexico, where it breeds in grain and grain products. It was found in this country in grain exhibits at the World's Columbian Exposition, but is not known to be permanently established in this country as yet. It may be found in grain in the extreme South.

SIAMESE GRAIN BEETLE

The Siamese grain beetle, *Lophocateres pusillus* Klug, is an elongate, flattened, reddish-brown beetle slightly less than an eighth of an inch long, characterized by the much flattened margins of the thorax and wing covers. (Fig. 46.)

First appearing in exhibits of rice and cereals from Siam, Liberia, and Ceylon at the World's Columbian Exposition, it has since been reported as injurious to stored grain and grain products in South Carolina and Texas. It is likely to be found in seaport towns and in the Southern States, but as yet it is not abundant or widespread.

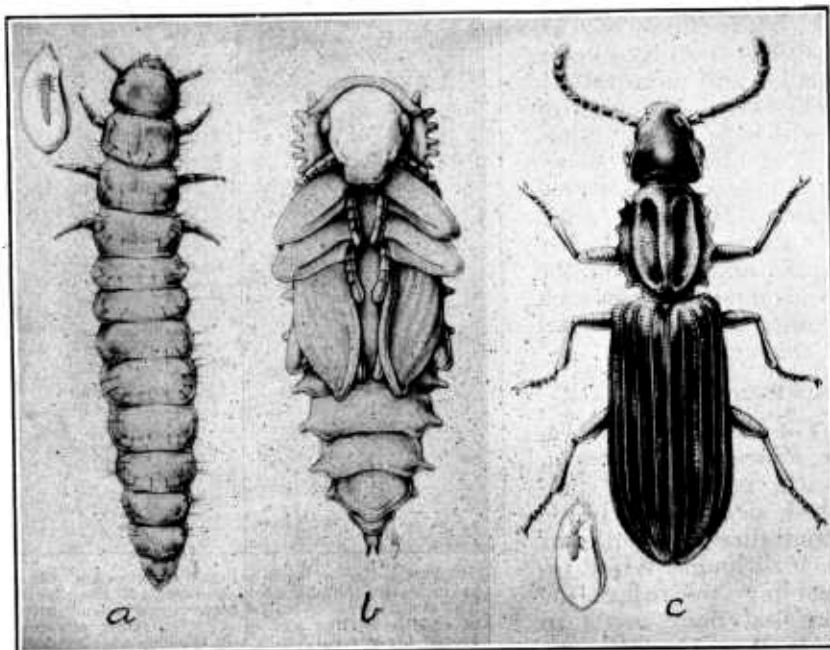


FIGURE 40.—The saw-toothed grain beetle: *a*, Well-grown larva, with kernel of wheat to show its relative size; *b*, pupa; *c*, adult beetle with kernel of wheat to show its relative size. The adult beetle, about one-tenth of an inch in length, can be easily recognized by the six toothlike projections on each side of the thorax.

FLAT GRAIN BEETLE

The flat grain beetle, *Cryptolestes pusillus* Schōn., is a small flattened, oblong, reddish-brown beetle about one-sixteenth of an inch long, with elongate antennæ somewhat longer than half the

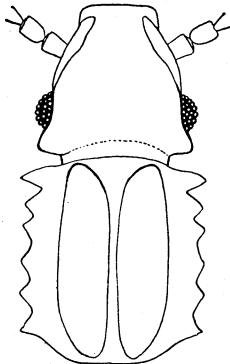


FIGURE 41.—Head and thorax of saw-toothed grain beetle

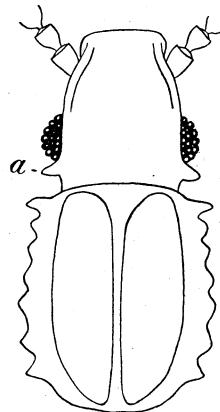


FIGURE 42.—Head and thorax of merchant grain beetle. Note the narrow, sharply projecting temples at *a*

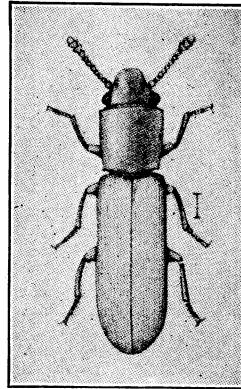


FIGURE 43.—The square-necked grain beetle. (Chittenden)



FIGURE 44.—The foreign grain beetle. (Chittenden)

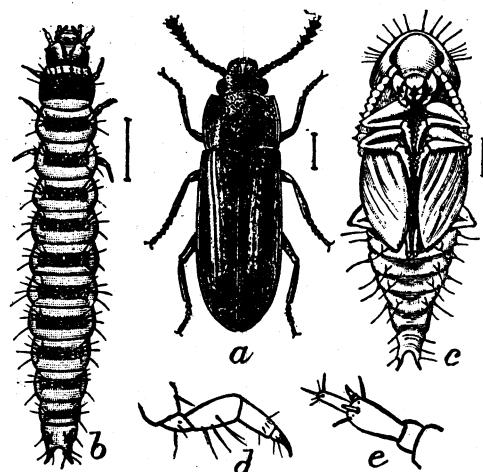


FIGURE 45.—The Mexican grain beetle: *a*, Beetle; *b*, larva; *c*, pupa; *d*, leg of larva; *e*, antenna of larva. *a*, *b*, *c*, Much enlarged; *d*, *e*, more enlarged

length of its body. (Fig. 47.) It is readily distinguished because it is the smallest beetle commonly found in stored grain in this country. It is cosmopolitan in distribution, is very generally found in stored corn in the South, and is often screened from wheat shipments. It is not a primary pest of stored grain, and the adult is

apparently unable to survive in sound, uninjured grain. It follows up the attack of the more vigorous grain pests and is frequently found associated with the rice weevil in enormous numbers. It is a scavenger by nature and often infests grain and meal that is out of condition.

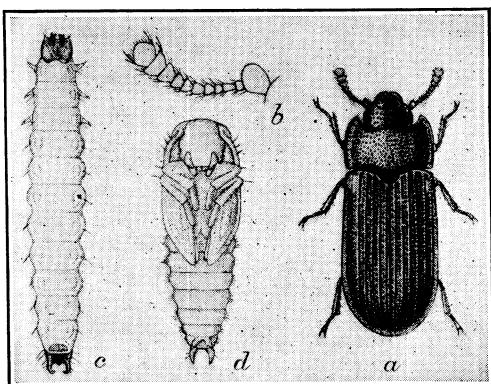


FIGURE 46.—The Siamese grain beetle. *a*, Beetle; *b*, antenna of same; *c*, larva; *d*, pupa. *a*, *c*, *d*, About 10 times natural size; *b*, greatly enlarged

inuous substance to which food particles adhere. They transform to the pupal stage in these cocoons and later emerge as adults.

RUST-RED GRAIN BEETLE

The rust-red grain beetle, *Cryptolestes ferruginous* Steph., is closely related to the preceding species and is similar to it in form, size, and habit. It is more resistant to cold weather than the flat grain beetle and is more commonly found in stored grain in the Northern States. The two species may be readily distinguished by the fact that in the flat grain beetle the antenna of the male is about as long as the body and is about twice as long as that of the female beetle, whereas in the rust-red grain beetle the antenna of the male is short. (Fig. 48.)

CONFUSED FLOUR BEETLE

The confused flour beetle, *Tribolium confusum* Duv. (fig. 49), is a shiny, reddish-brown beetle about one-seventh of an inch long, flattened and oval in form, with head and upper parts of thorax densely covered with minute punctures and with wing covers ridged lengthwise and sparsely punctured between the ridges. It is generally distributed over the world and is very abundant in all parts of this country. It is known as one of the flour beetles owing to its frequent occurrence in flour. It is a general feeder on starchy foods and is probably the worst insect pest of prepared cereal foods. It is

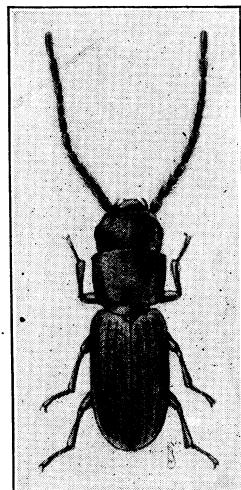


FIGURE 47.—Adult of the flat grain beetle, showing characteristic long antennæ. Not more than one-sixteenth of an inch long. This beetle is one of the very smallest found in grain shipments

constantly found in granaries, mills, and storehouses, and grain shipments.

The minute white eggs of this beetle are laid in the cracks and crevices of bins, barrels, boxes, or other containers of the foodstuffs attacked by this insect. They are covered with a sticky secretion, so that they become covered with flour, meal, etc., and readily adhere to the sides of sacks, boxes, and other containers so fresh material placed in them is rapidly infested. The eggs hatch into small worm-like larvæ, slender, cylindrical, and wiry in appearance. When fully grown they are about three-sixteenths of an inch long, and in color are white, tinged with yellowish. These larvæ feed on flour or other material such as grain dust and the broken surfaces of grain kernels. When full grown they transform to small naked pupæ. At first white, the pupæ gradually change to yellow and then brown, and shortly afterwards transform to beetles. The period from egg to adult in summer is about four weeks under most favorable weather conditions, though the life cycle is greatly prolonged by cold weather, as is true of all grain pests.

RUST-RED FLOUR BEETLE

The rust-red flour beetle, *Tribolium ferrugineum* Fab., is almost identical in appearance with the preceding species, to which it is closely related. It can be distinguished from the confused flour beetle only with the aid of a magnifying glass. The segments of the antennæ of the confused flour beetle increase in size gradually from the base to the tip, while in the rust-red flour beetle the last few segments of the antennæ are abruptly much larger than the preceding ones, giving the antennæ the appearance of being suddenly enlarged at the tip. In addition, the margins of the head of the confused flour beetle are expanded and notched at the eyes, while the margins of the head of this species are nearly continuous at the eyes. The differences between the two species are clearly shown in Figure 49, e and f.

This insect is similar to the confused flour beetle in feeding and breeding habits, and it is impossible to distinguish between the early stages of the two insects. Although cosmopolitan in distribution, it is found more commonly in the South, where it causes very serious damage to grain products. In addition to the actual damage caused by its feeding activities, serious losses are caused by the nauseous

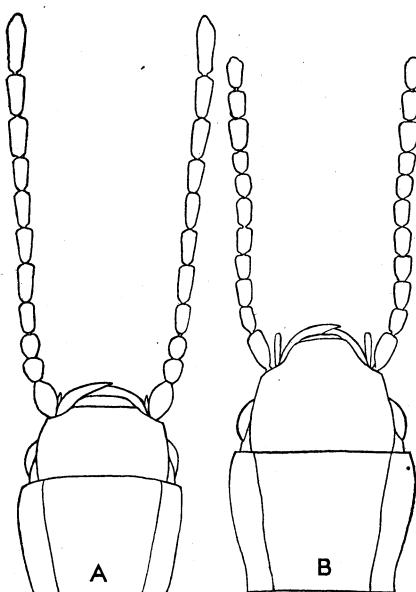


FIGURE 48.—Thorax, head, and antennæ of male beetles, showing the relative length of the antennæ as compared with those parts of the body in—*a*, the flat grain beetle; *b*, the rust-red grain beetle

smell and taste that it imparts to the material it infests. Like the confused flour beetle, the rust-red flour beetle is primarily a pest of milled products, and while present in grain shipments it confines its attack in these to grain dust and the surface of broken grains, hence is not a primary pest of commercial shipments.

LONG-HEADED FLOUR BEETLE

The long-headed flour beetle,¹ *Latheticus oryzae* Waterh., is a slender, flattened beetle, slightly less than an eighth of an inch long, somewhat similar in form to the confused flour beetle but pale yellow and further differentiated by the peculiarly shaped antennæ shown in Figure 50 and by the minute canthus behind each eye. It has been reported from most parts of the world infesting wheat, rice, corn, barley, rye, flour, etc. It was first recognized in this country

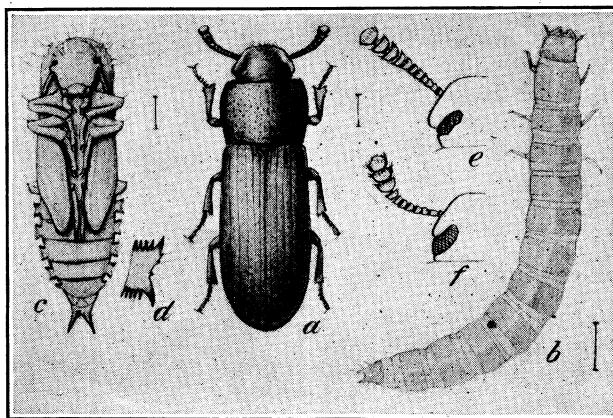


FIGURE 49.—The confused flour beetle, the commonest insect recovered from grain shipments. It is about one-sixth of an inch long. *a*, Beetle; *b*, larva; *c*, pupa; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of the rust-red flour beetle. (Chittenden)

about 13 years ago from specimens taken in Texas. It is not known to be very widely distributed in the United States, but is likely to be found in mills and granaries in the South.

BROAD-HORNED FLOUR BEETLE

The broad-horned flour beetle, *Gnathocerus cornutus* Fab., owes its name to the peculiar structure of the mandibles or jaws of the male beetle, which are armed with a pair of broad, stout horns as shown in Figure 52. It is a robust, reddish-brown beetle, about one-sixth of an inch long; closely resembling the other flour beetles in appearance, but easily distinguished by the peculiar structure of the jaws. It is cosmopolitan in distribution and occurs frequently in the Southern States. It prefers to feed in flour and meal, but is found in a variety of grains. The adult beetles frequently live for a year or longer, the females laying from 100 to 200 eggs each. The small

¹ A closely related species, *Latheticus prosopsis* Chittn., is shown in Figure 51.

white eggs hatch in from four to five days in warm weather, and development from egg to adult takes place in about eight weeks.

SLENDER-HORNED FLOUR BEETLE

The slender-horned flour beetle, *Gnathocerus maxillosus* Fab., is closely related to the preceding species and is of similar form and

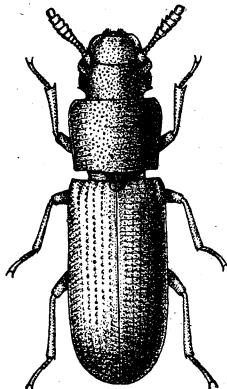


FIGURE 50.—Long-headed flour beetle. Chittenden

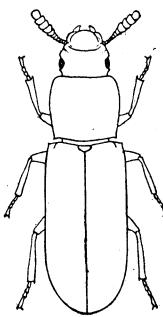


FIGURE 51.—*Latheticus prosopis*. (Chittenden)

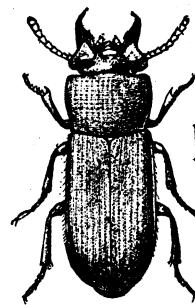


FIGURE 52.—The broad-horned flour beetle. (Chittenden)

appearance. It is about one-eighth of an inch in length, and, in addition to its smaller size, it may be distinguished from the broad-horned flour beetle by the shape of the horns with which the mandibles or jaws of the male are armed. In this species (fig. 53) the horns are slender and incurved. Its habits are similar to those of the preceding species.

SMALL-EYED FLOUR BEETLE

The small-eyed flour beetle, *Palorus ratzeburgi* Wissm. (fig. 54), is the smallest of the so-called flour beetles that infest grain and grain products in this country. It is a tiny, flattened, shiny, reddish-brown beetle, somewhat oblong in form and measuring about one-twelfth of an inch in length. It occurs throughout the world and is widely distributed in this country. It prefers ground products in which to breed, but is not infrequently found in stored grains.

A closely related species (*P. depressus* Fab.) more common in Europe but occasionally found in this country is very similar in appearance and habits to the small-eyed flour beetle.

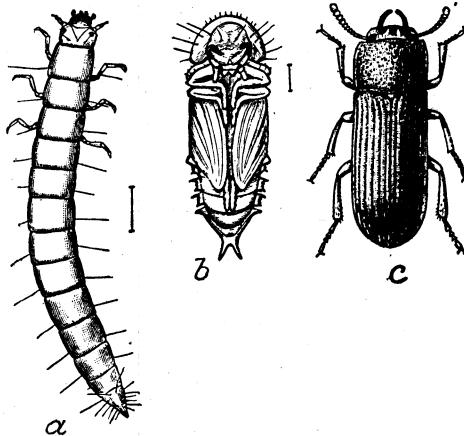


FIGURE 53.—The slender-horned flour beetle: a, Larva; b, pupa; c, beetle. (Chittenden)

TOBACCO BEETLE

The tobacco beetle, *Lasioderma serricorne* Fab., is a small, robust, oval, reddish-yellow or brownish-red beetle, with head bent down nearly at right angles to the body, giving the beetle a humped appearance when viewed from the side as shown in Figure 55. It varies in size, but is usually about one-tenth of an inch long. It is found in all temperate, subtropical, and tropical regions and infests tobacco and many other stored products. It breeds in a variety of seeds and may occasionally be found attacking grains left long in storage in original sacks.



FIGURE 54.—The small-eyed flour beetle. (Chittenden)

the wing covers distinctly striated. It is about one-tenth of an inch long. It is cylindrical and uniform light brown; its body is covered with a fine silky pubescence. (Fig. 56.) The larva or grub is very

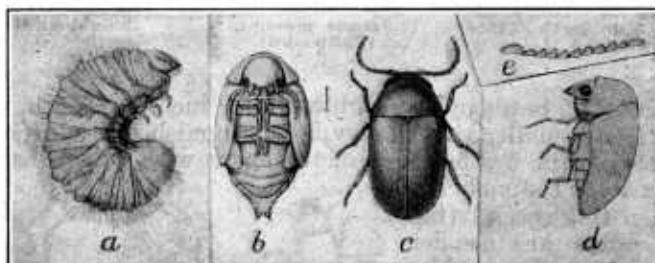


FIGURE 55.—The tobacco beetle never attacks grain unless it has been stored for long periods. a, Larva; b, pupa; c, beetle, dorsal view; d, beetle, side view; e, antenna of beetle. (Chittenden)

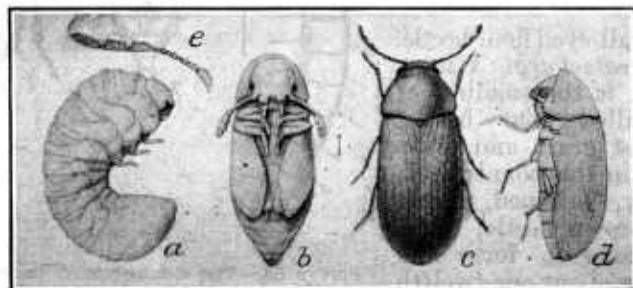


FIGURE 56.—The drug-store beetle never attacks grain unless it is stored for long periods unmolested. a, Larva; b, pupa; c, beetle, dorsal view; d, beetle, side view; e, antenna of beetle. (Chittenden)

much less hairy than that of the cigarette or tobacco beetle, as a comparison of Figures 57 and 58 will show. It is known as the drug-store beetle from its habits of feeding on almost all drugs found

in pharmacies. It is a very general feeder, attacking a great variety of stored foods, seeds, and other materials, and has been said to "eat anything except cast iron." It is frequently found in storehouses and granaries in all parts of the world.

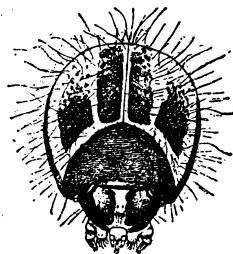


FIGURE 57.—The tobacco beetle: Head and larva. (Chittenden)

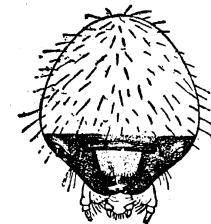


FIGURE 58.—The drug-store beetle: Head and leg of larva. (Chittenden)

The eggs of this beetle are laid in almost any dry organic substance. The small white grubs emerging from the eggs tunnel through these substances and when full grown pupate in small cocoons. The entire life cycle may be passed in less than two months.

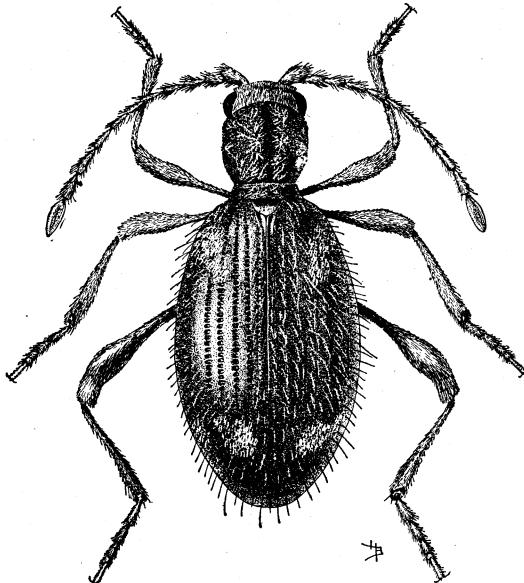


FIGURE 59.—The white-marked spider beetle, adult female. (The male is elongate-oval in shape and is not so conspicuously marked as the female)

WHITE-MARKED SPIDER BEETLE

The white-marked spider beetle, *Ptinus fur* L. (fig. 59), is occasionally found infesting stored grain and seeds of various kinds, but rarely causes serious damage. It is an omnivorous feeder, attack-

ing flour, meal, roots, seed, and miscellaneous stored foods. It is about an eighth of an inch in length, reddish brown with four white marks on the wing covers, and, owing to the length of its legs and antennæ, has a somewhat spidery appearance. The larva is white and closely resembles those of the tobacco beetle and the drug-store beetle. It has the habit of forming globular cases of the material in which it is feeding.

BROWN SPIDER BEETLE

The brown spider beetle, *Ptinus brunneus* Dufts., closely resembles the preceding species in size, color, general appearance, and habits. It may be distinguished from the white-marked spider beetle by the fact that the white markings of the wing covers are lacking.

CATORAMA BEETLE

Another beetle closely related to the drug-store beetle and the tobacco beetle and which has similar habits is the catorama beetle, *Catorama* sp., which is shown in Figure 60. It is shiny black and is about one-eighth of an inch long. It is only an occasional pest of stored grain and does not cause serious damage.

BLACK CARPET BEETLE

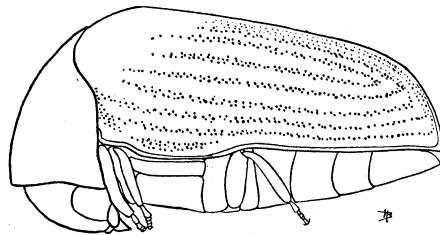


FIGURE 60.—The catorama beetle. This beetle is shiny black

yellowish in color. The larva is very characteristic and can be readily recognized. It is reddish or golden brown, clothed with short scalelike appressed hairs and provided with a tuft of long hairs at the end of the body, as shown in Figure 61.

As the name indicates, this insect injures carpets, but in addition it is known to breed in grains and cereals, both whole and ground. The larval stages develop very slowly, and there is but one generation each year. The adults appear in greatest numbers during the spring and early summer. It occurs in Europe and Asia and has been reported from all parts of this country. It is of very common occurrence in houses.

LARGER CABINET BEETLE

The larger cabinet beetle, *Trogoderma tarsale* Melsh., is a small, oval beetle about one-eighth of an inch long, its ground color black mottled with reddish brown, covered with gray and light-brown scalelike hairs forming a distinct pattern on the wing covers. The larva somewhat resembles that of the black carpet beetle in appearance. It is about one-eighth of an inch long, reddish brown above and whitish beneath, with body covered with short yellowish-brown

hairs and with a tuft of short hairs at the tail end. (Fig. 62.) It is well known for its habit of breeding in dead insects and animal substances and is not infrequently found living in grain, flaxseed,

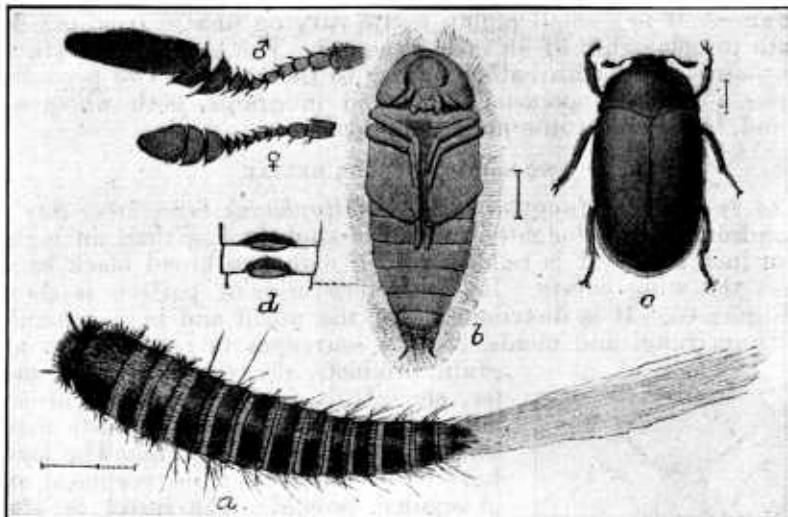


FIGURE 61.—The black carpet beetle is chiefly a pest of sample grains, or found in grain dust about elevators or storage bins. *a*, Larva; *b*, pupa; *c*, beetle; *d*, dorsal abdominal segments of pupa; *♂*, antenna of male beetle; *♀*, antenna of female beetle. (Howard)

castor beans, pumpkin seed, etc. It often becomes a nuisance in laboratories by attacking sample lots of corn, wheat, etc.

SMALL CABINET BEETLE

The small cabinet beetle, *Anthrenus verbasci* L., is somewhat similar in appearance to the larger cabinet beetle but smaller and of different color. It varies in length from one-sixteenth to two-sixteenths of an inch, and is black with yellowish-white scales that form a broad band across the back and give the body a mottled appearance. The habits of the adult and early stages of this insect are similar to those of the larger cabinet beetle. It is occasionally found in flour mills and granaries, where it infests grain and grain products.

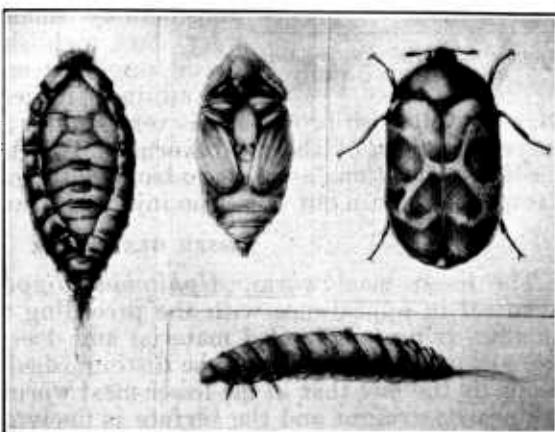


FIGURE 62.—The larger cabinet beetle: At left, pupa within larva skin; in center, pupa; at right, beetle; below, well-grown larva

MUSEUM BEETLE

The museum beetle, *Anthrenus museorum* L., is closely allied to the preceding beetle and resembles it in size and form. Its body is black, covered with yellowish and whitish scales; giving it a spotted appearance. It is a small plump beetle varying in size from one-sixteenth to one-eighth of an inch in length. The larvæ are small, active, hairy grubs with habits similar to those of the two preceding species. They are occasionally found in grains, both whole and ground, but do not cause noticeable damage.

TWO-BANDED FUNGUS BEETLE

The two-banded fungus beetle, *Alphitophagus bifasciatus* Say, is a handsome little elongate-oval beetle slightly less than an eighth of an inch long. It is reddish brown with two broad black bands across the wing covers. Its characteristic color pattern is shown in Figure 63. It is distributed over the world and is in general a feeder on fungi and molds, being a scavenger in refuse grain and grain products, decaying vegetable matter, etc. It is frequently found around mills and storehouses where waste material is allowed to accumulate. The larvæ have been bred from moist cornmeal and in spoiled cereals. The insect is often found in the holds of grain ships in wet or damaged grain.

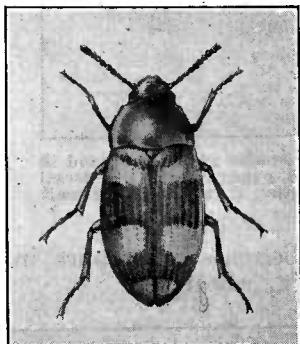


FIGURE 63.—The two-banded fungus beetle. Adult

BLACK FUNGUS BEETLE

The black fungus beetle, *Alphitobius piceus* Oliv. (fig. 64), resembles the meal-worm beetles in form and color but is considerably smaller. It is black or a very dark reddish brown and measures from three-sixteenths to four-sixteenths of an inch in length. The larva (fig.

64, a) is yellowish brown and is very similar in form and appearance to young larvæ of the meal worms. This beetle is often found in the same situations as the two-banded fungus beetle. It breeds in damp moldy grain but causes no injury to grain that is sound and dry.

LESSER MEAL WORM

The lesser meal worm, *Alphitobius diaperinus* Panz., is almost identical in appearance with the preceding species and has similar habits. It prefers spoiled material and does not cause serious damage to sound grain. It may be distinguished from the black fungus beetle by the fact that in the lesser meal worm the sides of the thorax are nearly straight and the surface is finely and sparsely punctured, whereas in the black fungus beetle the sides of the thorax are curved and the surface is coarsely and profusely punctured.

CORN SAP BEETLE

The corn sap beetle, *Carpophilus dimidiatus* Fab., may be readily recognized by its peculiar wing covers, which are short and truncate, leaving the tip of the abdomen exposed as shown in Figure 65. It is a

small, dark-brown beetle with lighter colored wing covers, oblong-ovoid in shape, and varying in length from one-tenth to one-eighth of an inch. It normally feeds in rotting and decaying fruit and vegetation and in the sap exuding from injured plants. It is quite numerous in

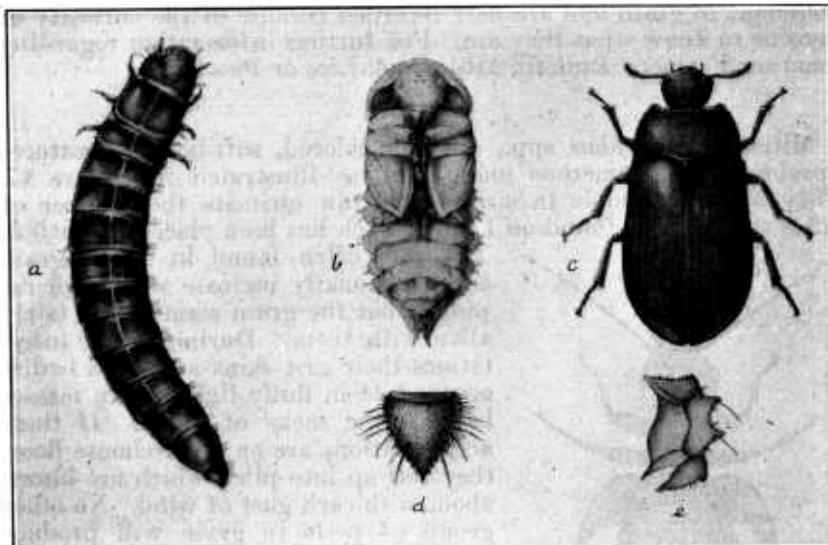


FIGURE 64.—The black fungus beetle: *a*, Larva; *b*, pupa; *c*, adult; *d*, caudal segment of larva (Schiödte); *e*, lateral plate of pupa. (Schiödte)

cornfields in the South, swarming over the damaged ears and feeding and breeding in the decaying kernels. It is attracted to damp and decaying grain but is seldom found in grain that is clean and dry.²

A closely related beetle (*Carpophilus humeralis* Murray) that has been introduced from abroad and is becoming more and more abundant is similar in form to the corn sap beetle, but is slightly larger and is uniform, shiny, dark brown all over. Its habits are very similar to those of the preceding species.

BOOK-LICE OR PSOCIDS

Book-lice or psocids, *Troctes divinatoria* Fab. *et al.*, are minute, pale, soft-bodied, louselike insects, about one thirty-second of an inch long, with long, slender antennæ, differing greatly in appearance from other grain-infesting



FIGURE 65.—The corn sap-beetle. Adult

insects. (Fig. 66.) They may be whitish, almost transparent, or quite dark.

² *Carpophilus pallipennis* Say, a purely flower-infesting beetle, has been occasionally reported as infesting stored corn. In these cases large specimens of the corn sap beetle which closely resemble this species were probably mistaken for it.

Psocids are of very common occurrence and may be found in nearly any situation. They are almost omnivorous, feeding on any animal or vegetable matter. They are frequently found in grain, but while they have jaws and are capable of feeding upon solid materials, they may be disregarded as pests of grain. They are frequently very abundant in grain and are here recorded because of the curiosity of persons to know what they are. For further information regarding them see Farmers' Bulletin 1104, Book-Lice or Psocids.

MITES

Mites, *Tyroglyphus* spp., are pale-colored, soft-bodied creatures provided with numerous long hairs, as illustrated in Figure 67. They are microscopic in size. As a low estimate the number of mites that may be found on 1 square inch has been placed at 100,000.

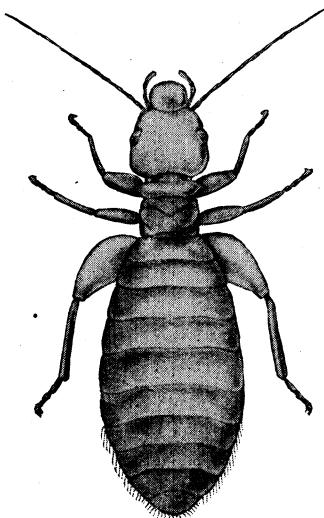


FIGURE 66.—Book-louse or psocid

will usually reduce mite infestations to a point where no injury takes place.

PARASITES OF GRAIN PESTS

Grain in bulk is often seen swarming with small, black, wasplike insects of a size and appearance shown in Figure 68. These do not cause injury to grain. On the contrary, they are beneficial, as they are attacking and killing the grain weevils and grain moths. While parasites kill a large number of grain insects they unfortunately can not be considered of great importance from the standpoint of grain protection, for by the time the grain insects have been controlled by parasites the grain itself has become very badly damaged. For this reason the appearance of a large number of parasites in grain cars or elevators should be disregarded and the grain treated as though parasites were not present.

Grain dealers frequently find a small threadlike white worm, *Scenopinus fenestralis* L. (fig. 69), about three-quarters of an inch long in grain dust beneath sacks or in the bottoms of bins. This

is the larva of a small black fly to be found crawling upon windows of granaries and flour mills. Because of this habit it is called the window-pane fly. Its threadlike larva does no harm to grain but is predacious upon the larvae of grain pests and clothes moths. It is not abundant enough to be of value in protecting grain.

HOW GRAIN BECOMES INFESTED

Grain may become infested in a number of ways. It is never possible to settle satisfactorily litigation over responsibility for insect damage to grain without a thorough knowledge of the history of the particular grain shipment involved.

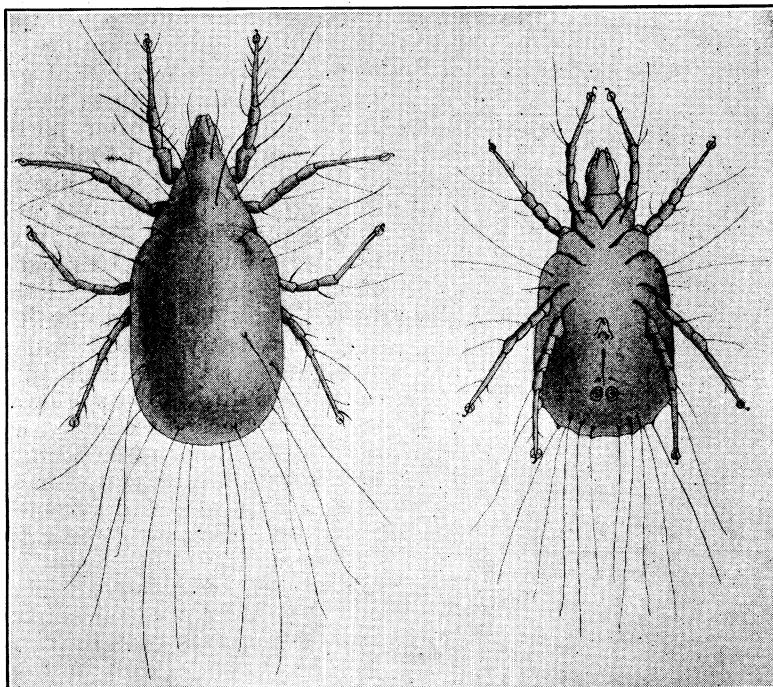


FIGURE 67.—Grain mites. (Howard)

Several of the worst insect pests of grain, notably the Angoumois grain moth and the rice or black weevil, fly to the grainfields from near-by cribs and begin their attack upon the maturing grain. In the case of wheat and similar small grains, the eggs of the insect are laid directly upon the heads of grain. In the case of corn the insects can infest only those kernels that are exposed because of poorly developed or damaged shuck covering. In cornfields, especially in the South, where insect infestation occurring in the field is most severe, there are a sufficiently large number of exposed kernels to bring about slight, though widespread, infestation.

It is probably true that in well-grown crops of corn the percentage of kernels infested before the crop is ready for harvest is very small, and throughout the Middle and Northern States is a negligible factor. In the Gulf Coast States, especially in upland fields, the infes-

tation often is very severe. In the case of wheat, grown particularly along the Ohio River, in southern New Jersey, in Pennsylvania, Maryland, Delaware, Virginia, and southward, the field infestation may be much more general than is now believed. Newly threshed wheat from Maryland arriving in September on the Baltimore market showed infestation ranging up to 6 per cent. While these infestations occurring in the grain before it is harvested are usually unavoidable, they are of great importance as "leaven" which in storage may result in a general infestation of an entire crop, in heating, and in much damage.

After grain has been harvested it is often stored in bins, storehouses, or barns that have held, or still hold, infested grain and which have not been thoroughly cleaned. Wooden bins and wooden partitions in grain storehouses and in the holds of grain-carrying ships become the nesting places for an incredibly large number of grain pests. Certain of these can and do bore into the softer portions of the partitions and timbers that are used over and over again as dunnage, and the excavations they make serve as hiding places, not only for themselves but all other species associated with them. Unless such bins and partitions are thoroughly disinfected by fumigants, these hidden insects can not be killed. The mere spraying of contact insecticides upon the walls will not reach them. If uninfested grain is placed in such bins, it naturally will become infested by the insects coming from the bin walls.



FIGURE 68.—Hymenopterous parasite of grain pests. Adult parasite resting upon a kernel of wheat. These tiny gnatlike insects are beneficial but their help usually comes too late to prevent damage to the crop in which they are most abundant.

insects unless they have been treated by heat or fumigation. Certain extensive and costly infestations have been traced directly to the use of secondhand untreated grain sacks.

Grain stored in the open or in poorly constructed cribs or bins may become infested by insects flying in from outside sources.

HOW TO PREVENT PRIMARY INFESTATION

Infestation of grain in the field can not be entirely prevented, but by proper precautions it can be reduced to a minimum. The first generation of insects in the maturing grain is usually small, and if the grain is cut as soon as ripe, threshed as soon as dry, and then placed in storage in clean, deep bins the damage from this source will be very slight. It is when the grain is left in the field long after it is ripe that serious infestation results, for the insects increase in one or two generations to enormous numbers. In the case of corn

in the field, only those ears that are damaged or through poor shuck development have kernels exposed are subject to the attack of grain insects. Farmers should therefore grow a variety of corn that develops a long tight shuck.

Newly harvested small grains should not be stored unthreshed for any length of time, as in this condition they are very susceptible to infestation. If promptly threshed and stored in deep bins, only a thin layer on top of the bin is likely to become infested. Corn may be stored in the shuck if the husk is long and tight and fully covers the tip, but all ears with loose, broken, short, or damaged husks should be shucked and stored separately.

Clean grain should never be stored in old bins, granaries, or storehouses until they have been thoroughly cleaned and freed from the accumulations of waste grain and other materials harboring grain insects. Timbers in bins, granaries, or holds of ships that have become infested with grain insects should be destroyed or treated before being used again. Steel or concrete bins are highly desirable owing to the ease with which they are cleaned.

Bags of all kinds that have previously held grain should not be allowed in granaries or warehouses or be refilled until they have been sterilized by heat or otherwise freed from insects. The use of tight cribs will keep the grain free from infestation by insects that might fly in from the outside.

THE TREATMENT OF INFESTED GRAINS

Insects infesting stored grain can be destroyed by the use of heat, or by fumigation with poisonous gases. These remedial measures are mentioned only briefly in this bulletin.

HEAT

A temperature of 120° to 130° F., maintained for a short time, will kill all stages of grain-infesting insects, without injuring the germinating quality of the grain. Owing to the difficulty of subjecting the grain to such a temperature this method of control is used chiefly by millers and large grain dealers who are equipped with commercial driers suitable for the purpose.

FUMIGATION

Carbon disulphide, carbon tetrachloride, and hydracyanic-acid gas are the fumigants in most common use to-day for treating infested grain. All things considered, carbon disulphide is the most effective fumigant for treating grain in bulk. It is a colorless liquid



FIGURE 69.—Larva of a kind of fly that preys upon grain beetles and mites. This white threadlike worm is sometimes found in grain dust and attains a length of about three-fourths of an inch; while interesting, it is of no practical value.

which evaporates on exposure to air, forming a vapor that is heavier than air. If applied at the top of a gas-tight bin of grain, the gas will penetrate down through the grain, killing the insects without injury to sound grain.

Carbon disulphide has the great disadvantage that its vapor is highly inflammable and when mixed with certain proportions of air will explode if ignited. Notwithstanding this fire hazard, which must always be taken into consideration, carbon disulphide is in general use on farms for the protection of grain in cribs. For further information on fumigation with carbon disulphide see Farmers' Bulletins 799, 1029, and 1483, published by the United States Department of Agriculture.

Carbon tetrachloride is not very effective as a grain fumigant when used alone, but, owing to its noninflammability it is used extensively in the manufacture of grain fumigants containing small quantities of more powerful but inflammable compounds. Several such mixtures containing carbon tetrachloride, sulphur dioxide, and a small quantity of carbon disulphide are in common use. They are less effective than carbon disulphide alone, but considerably more effective than carbon tetrachloride and, while not entirely free from fire hazard, they are much safer than carbon disulphide.

Hydrocyanic-acid gas generated from calcium cyanide has been used to some extent during the last few years to fumigate grain in large elevator bins. The calcium cyanide, in a finely divided state, is incorporated into the flow of wheat as it enters the bin. Hydrocyanic-acid gas generated from calcium cyanide so distributed through the mass of wheat in the proportion of 25 pounds of the chemical to 1,000 bushels of wheat will, according to the experiments of some, kill all the weevils and does not injure the grain for milling purposes. Grain so treated, however, may temporarily carry an odor, and while this odor ordinarily seems to be of no consequence from the milling and baking standpoint, the grain will be sample graded by Federal inspectors should the odor be considered permanent. This type of fumigation is a highly specialized one, calling for the use of patented equipment.

Chloropicrin is a noninflammable fumigant highly toxic to grain insects. Owing to the fact that it is a tear gas and relatively expensive, its use as a grain fumigant has been limited. The development of better methods of application may greatly increase its use for this purpose.

Ethylene oxide, a newly developed fumigant, shows promise of becoming a valuable fumigant for stored grain. Used in the proportion of 2 pounds for 1,000 cubic feet of space it appears to be effective against grain insects when used in combination with carbon dioxide. The mixture is best suited for use in grain elevators where equipment is available for mixing the material with the grain as the bins are being filled. The ethylene-oxide mixed with carbon dioxide, when used as recommended, is noninflammable and nonexplosive.

Further information regarding the control of grain pests will be found in Farmers' Bulletin 1483, Control of Insect Pests in Stored Grain.

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